Division of Agricultural Sciences

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AN ANALYSIS OF COSTS OF PROCESSING STRAWBERRIES FOR FREEZING

Carleton C. Dennis

CALIFORNIA AGRICULTURAL EXPERIMENT STATION
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

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FOREWORD AND ACKNOWLEDGMENTS

This is the second in a series of research reports on the frozen deciduous fruit and vegetable industry. The first report dealt with a survey of the industry on the Pacific Coast. Future reports will include additional studies of processing plant costs and efficiency, freezing costs, demand and price relationships of frozen foods, and interregional competition in the industry. These studies are being made under a regional research project by the Experiment Stations of the states of California, Oregon, and Washington and the Territory of Hawaii in cooperation with the Agricultural Marketing Service, U. S. Department of Agriculture.

This report concerns costs and efficiency in plants processing strawberries for freezing while a future report will cover the freezing operation. It is based on studies of operations of California frozen fruit and vegetable plants made in 1956 and 1957.

The author is indebted to Robert H. Reed, Agricultural Marketing Service, U. S. Department of Agriculture, for important contributions in securing the cooperation of the plants studied and in collection of the basic data of this study. Special credit is due to L. L. Sammet, Specialist in the Experiment Station, University of California, who was consulted frequently in planning the study and in the analysis and who has substantially influenced the preparation of this report.

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AN ANALYSIS OF COSTS OF PROCESSING STRAWBERRIES FOR FREEZING

by

Carleton C. Dennis[1]

INTRODUCTION

The Pacific Coast states are the major source of the national frozen strawberry supply, a position which has been achieved by very rapid growth in recent years. In the ten-year period, 1946-1956, total annual production of frozen strawberries in the western region of the United States increased from 78,000,000 to 255,000,000 pounds. The 1946 output of this region represented only about 48 per cent of the national frozen strawberry supply while the 1956 output was about 82 per cent. This rapid growth in frozen strawberry production in certain areas has required corresponding expansion in processing facilities.[2]

During this period of rapid expansion, the freezing industry has adapted many existing cannery techniques but also has developed processing and handling methods peculiar to its own needs. Fairly standardized techniques are used for many of the operations performed. For some operations, however, there are several methods currently in use, and for these the plant manager or owner contemplating the construction of a new plant or change in an existing plant needs information as to relative costs. This report is intended to supply this kind of information as well as an over-all description of the strawberry processing operation and an estimate of processing costs under California conditions. It is also expected to furnish a basis for comparing processing costs in different regions of the country and in this way contribute to future studies of the relative advantage of strawberry production in these regions.

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[1] Cooperative Agent of the Experiment Station, University of California, and the Agricultural Marketing Service, U. S. Department of Agriculture.

[2] The term "processing" is used in this report to include all the activities involved from receiving the raw product at a freezing plant to moving the packaged, unfrozen product to the plant exit. It does not include freezing.

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Source of Data

Data on labor and equipment utilization and costs were obtained through time and production studies, equipment inventories, processor interviews, and accounting records in seven California strawberry processing plants in 1956 and 1957. In these plants capacity output rates range from approximately 7,500 to 25,000 pounds per operating hour. Similar data were obtained in ten plants processing Lima beans for freezing, and this provided additional information for certain cost components. Data concerning equipment costs and operation were also obtained from several major equipment manufacturers, custom manufacturers, and contractors.

Labor Standards

Labor standards were developed for each of the jobs performed in strawberry processing plants as a basis for calculation of labor requirements when using each of the available techniques.1/ These standards are considered to be the continuous output rate which a reasonably efficient worker should attain. They do not represent the average or the best output achieved, but a check against actual labor utilization indicates that they do lie between these extremes.

Time and production studies were used wherever this technique was applicable to determine the amount of working time required to perform each of the jobs done in strawberry processing. An allowance of 15 per cent of total work time was then made for nonproductive time such as unavoidable delay, rest periods, and personal time. This gave the total per unit time from which units of output per hour were computed. For example, it was found that 0.0971 minute was required to set an empty strawberry crate from a conveyor to a pallet, including miscellaneous activities required to perform this job such as obtaining and placing empty pallets. With the allowance for nonproductive time, the total time per crate is 0.1142 minute. This figure, divided into 60 minutes, gives a work standard of 526 crates per hour.

1/ These standards with descriptions of the jobs performed are listed in Appendix Table A.

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[illegible]

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[illegible]

Accounting record data were utilized to determine job standards in those cases, such as sorter and utility labor, where time and production studies are not well adapted. As with the data from time and production studies, analysis of the accounting record data was designed to provide estimates of potential performance rates at levels of above average but less than the maximum achieved rates.[1/]

The number of workers required for each job when operating at various output rates was then determined on the basis of one worker for each multiple and additional fraction of the applicable job standard. The current wage rates (1958) of the Collective Bargaining Agreement between the Frozen Food Operators and the California State Council of Cannery Unions were applied to these requirements to determine hourly labor cost with respect to method used and output capacity.

Equipment

Equipment output capacities were estimated from plant observations, estimates of managers, and specifications of manufacturers. Installed equipment replacement costs were based on manufacturer quotations and contractor installation estimates which include electrical work and connection to primary water lines.[2/] Wherever there were price differences in regard to a given type of equipment, the lowest price of equipment capable of accomplishing the desired objective with comparable efficiency was used. This is consistent with the objective of the study--to determine the lowest cost methods of processing strawberries for freezing--even though the higher price equipment may have certain advantages not possessed by the less expensive equipment.

With each available technique, the lowest cost combination of equipment needed in each stage at given output rates was calculated on the basis of estimated equipment output capacities and installed prices.

[1/] For example, see page 14 for the use of such data in developing production standard for quality sorting.

[2/] These costs were obtained in 1957 but are applicable to the 1958 processing season since they had not changed significantly through the first half of that year.

Total Cost Estimation

Using the performance standards described above, labor and equipment requirements in relation to output rate were determined for each technique available to perform the operations required in strawberry processing. Appropriate wages, equipment replacement, and variable operating costs were applied to these physical requirements to determine, for each technique, total costs of operation. With such estimates, comparison of costs and selection of the most efficient techniques for various sizes of plants and lengths of season can be made. The plant was divided into several independent parts to simplify the cost analysis, and total plant costs are the combination of the costs of these parts.

These costs, being built on labor and equipment performance standards, are not the actual costs of one or a sample of plants but represent costs of "synthesized," efficient plants. They represent cost levels that are attainable in well-organized, efficiently operated plants.

PLANT ORGANIZATION AND COST COMPONENTS

Several operations, as indicated by the process flow diagram (Figure 1) and a representative processing plant floor plan (Figure 2), are involved in processing strawberries for freezing. When the berries are received at the plant, they are first weighed and usually set aside to await processing. They are transferred from this temporary storage to a dump station, dumped, washed, and conveyed over quality inspection belts where they are manually sorted to remove debris and defective berries. The graded berries then go through a cable or sieve sizer.

Following the sizing operation, different operations may be performed--depending upon the final product. The berries may be packed either whole or sliced. Whole berries are directed from the sizer to the package-filling operation. Berries to be sliced are conveyed to the slicer, mixed with sugar, and then moved to the package fillers. After filling, 30-pound containers of either whole or sliced berries are placed on pallets to be taken to the freezer while smaller containers are placed in corrugated paper cases before palletizing.

These activities can, for convenience of analysis, be grouped into several production stages--each of which may consist of one or a group of closely related activities. These stages are selected to allow independent cost analysis

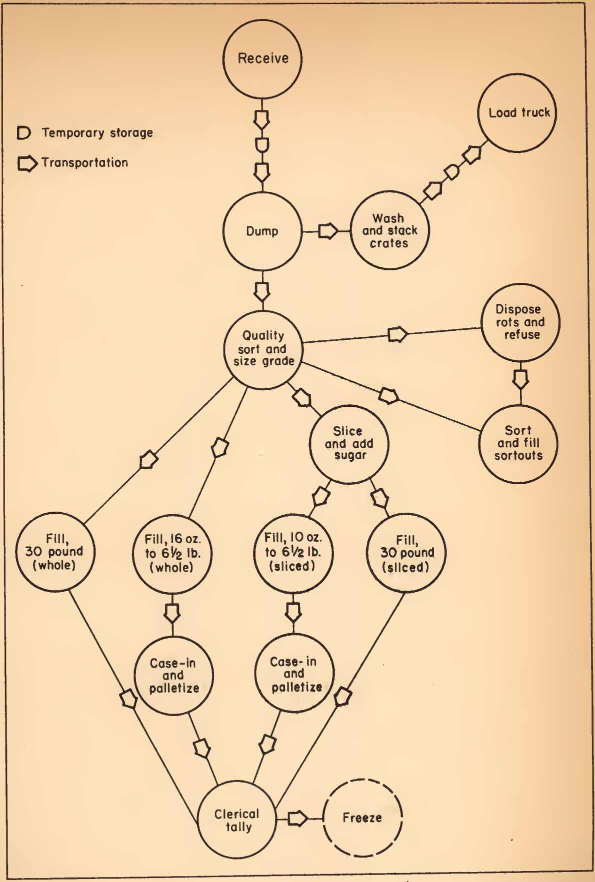
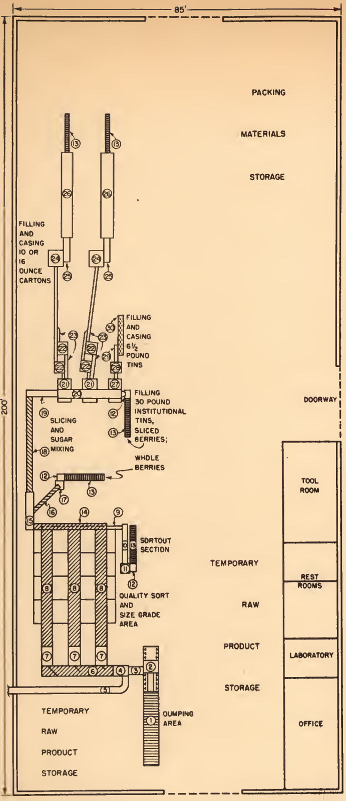


Figure 1. Process Flow Diagram for Strawberry Processing Plants, California, 1958



LEGEND

1. Pallet conveyor
2. Dump platform
3. Crate conveyor
4. Dumper
5. Empty crate conveyor and washer
6. Berry conveyor, dumper to shaker-washer
7. Shaker-washer
8. Inspection belt, inclined with sorting platform
9. Sortout flume
10. Dewatering belt
11. Sortout hopper
12. Scale
13. Conveyor, steel roller
14. Berry conveyor, inspection belt to size grader
15. Size grader
16. Conveyor, whole berry
17. Whole berry hopper
18. Berry conveyor, size grader to slicer
19. Slicer and sugar mixer
20. Holding tank, sliced berry
21. Carton filler, 10 and 16 ounce
22. Carton closer, 10 and 16 ounce
23. Conveyor, carton
24. Carton caser, 10 and 16 ounce
25. Case conveyor
26. Case sealer and compressor
27. Filler, 6½-pound tin
28. Closer, 6½-pound tin
29. Conveyor, 6½-pound tin
30. Conveyor, skate, (case-in)

Figure 2. Floor Plan for a Representative Medium Size Strawberry Processing Plant. California 1958

of each segment of the total plant. Within some of the stages, there are alternative methods or techniques which can be used to perform a given operation. This means that there are several ways of organizing a plant. For each size of plant and length of season, there is a least-cost technique within each stage and a least-cost organization utilizing a combination of least-cost stages.

The plant stages, together with several categories of indirect costs not associated with a specific stage, form plant cost components. The cost components considered in this study are (1) dumping, (2) quality sorting and size grading, (3) slicing and the sugar system, (4) container filling, (5) casing, (6) receiving, checkout, and in-plant transportation of products and materials, (7) miscellaneous equipment and materials, (8) supervisory and miscellaneous labor, (9) office and administrative expense, and (10) building costs.

STAGE ANALYSES AND INDIRECT COST COMPONENTS

Dumping

In the dumping stage field crates are taken from an adjacent pallet and dumped, the crates and berries are washed, and the crates restacked on a pallet for return to the producer. Two methods, differing only in the dumping phase, were observed in the plants studied. Workplace arrangements for these methods, called "manual" and "mechanical" to describe the actual dump operation, are shown in Figures 3 and 4.

With the manual dump the crate-dump worker takes a crate from the pallet; turns and places the crate against a bar on the dump hopper; dumps the crate slowly; completing the dump by tapping the inverted crate on a bar over the hopper; and then places the crate on the crate-washer conveyor. In a plant with mechanized dumping, a set-on man transfers the crates singly from the pallet to a conveyor which leads to the mechanical dumper. The crate passes though the dumper and onto the crate-washer conveyor. The berries are dumped onto a wide conveyor belt which carries them to the shaker-washers. Shear gates remove the berries from the belt, dividing them among the inspection lines as desired.

Several alternative mechanical dumpers and distribution systems have been discussed with plant operators and equipment manufacturers. The mechanical

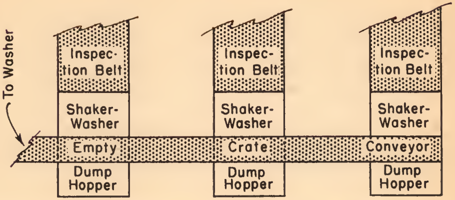


Figure 3. Workplace Arrangement for Manual Strawberry Dumping in a 15,000-Pound-Per-Hour Input Capacity Plant, California, 1958

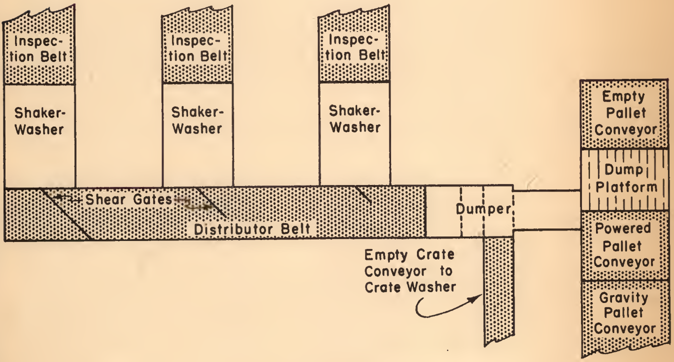


Figure 4. Workplace Arrangement for Mechanical Strawberry Dumping in a 15,000-Pound-Per-Hour Input Capacity Plant, California, 1958

crate dumper considered in this report is an adaptation of a box dumper developed primarily for use in prune packing. This machine guides the crate off the end of a conveyor, dumps the berries, and deposits the empty crate on the crate-washer conveyor. There are at least two additional box dumpers which are used for other products and probably could be adapted to use for strawberries. These are the chain-type, single-box dumper which tips the box as it moves along a conveyor and the drum type which picks the box up beneath a large drum and carries it over the drum, inverting it and depositing the berries onto a belt.

Variations in distribution methods include substitution of a water bath for the wide conveyor belt as a receiver for the berries and fluming, rather than conveying, the berries to the shaker-washers. A second possibility is to dump the berries directly into a large shaker-washer--substituted for the individual washers used on each inspection line--then to flume the berries to individual dewatering belts leading to each inspection line. Both methods are nearly equal in equipment replacement cost to the mechanical dump and conveyor belt distribution system considered here. However, dumping to a large shaker-washer would be less practicable when converting from manual to mechanical dumping because of probable loss in disposal of existing standard shaker-washers. Manual dumping to a water bath and fluming to inspection belts is a method which could result in costs approximately midway between the two methods considered in this study for plants operating at over 10,000 pounds per hour. Size grading before sorting, a technique which is applicable only to large plants, alters the plant equipment layout but has negligible effect on dumping costs.

The actual rate of dumping with the manual method varied in the plants studied from 190 to 400 crates per hour. Within the capacity of the dumper, however, this rate is governed by the flow of fruit required by the inspection line, and the dumper adjusts his pace to this rate so as to maintain the proper flow of fruit. The studies indicated that a rate higher than the maximum observed, probably as high as 650 crates per man-hour, could be maintained by an average worker. However, since the grading-line capacities observed in most plants approximated 5,000 pounds of berries per hour,[1] equivalent to about 355 crates per hour, this becomes the practical operating rate for this job as presently organized.

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[1] See discussion of sorting labor on page 15 .

With the machine-dump method, the manual job elements of emptying the crate and placing it on the empty-crate conveyor are eliminated and a higher capacity rate of approximately 1,200 crates per man-hour is estimated for the set-on operation that remains. To maintain this rate, however, most workers would require relief by occasional shifts to easier jobs such as empty-crate stacking or utility operations.

Table 1 gives, for the above methods, the crate-dumping labor and equipment requirements and costs in plants of six different sizes. The index of plant size in this table is the number of inspection lines. This is a practical basis for comparison since inspection belt design and capacities were highly standardized among the different plants studied. As shown in the table, one worker per inspection line is required for manual dumping. When using a mechanical dump, one dump worker is adequate for plants ranging from one to three lines in size. To supply four lines, two workers are required; but to minimize equipment investment, it is assumed that the manual dump method will be used for the fourth line. In five- and six-line plants, two workers and two machine-dumping units are provided.

Hourly variable costs--composed of charges for labor, power, and variable equipment repairs and maintenance--are shown to be less for manual than for mechanical dumping only in small one-belt plants. While variable costs increase with size of plant using either dumping method, they increase at a more rapid rate with manual than mechanical dumping. This is due to greater labor requirements of the manual method in large plants. However, annual fixed charge of the mechanical dump is greater than for the manual dump at all plant sizes.

The machine dump is a high-volume method capable of serving several inspection lines and, therefore, becomes a more economical method as size of plant increases. This effect is shown in Figure 5 where total costs with three different lengths of operating season are given with respect to output rate. In this chart the estimated costs based on Table 1 are shown by the lightly drawn cost lines. From these cost lines, comparison of the two dumping methods gives the annual savings (or loss) of a mechanical dump. Manual dumping is superior to mechanical dumping in plants employing only one inspection belt because the mechanical dump requires additional equipment expense and has no compensating laborsaving in this case. However, moderate savings

TABLE 1

Field Crate Dumping Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge with Respect to Method Used and Size of Strawberry Processing Plant, California, 1958

Input capacity (pounds per hour)	Workers required[a/]		Variable costs per hour			Equipment replacement cost and annual fixed charge[b/]						
	Dump[c/]	Set off empty crate[c/]	Labor[d/]	Power and repair[e/]	Total[f/]	Dumper	Crate washer with conveyor	Shaker-washer	Pallet conveyor	Distributor conveyor	Total replacement cost	Annual fixed charge
	number		dollars									
	Manual dump											
5,000	1	1	3.82	.17	3.99		1,455	1,445			2,900	479
10,000	2	2	7.63	.27	7.90		1,539	2,890			4,429	731
15,000	3	2	9.54	.35	9.89		1,623	4,335			5,958	983
20,000	4	3	13.36	.43	13.79		1,707	5,780			7,487	1,235
25,000	5	4	17.17	.53	17.70		1,791	7,225			9,016	1,488
30,000	6	4	19.08	.62	19.70		1,875	8,670			10,545	1,740
	Mechanical dump											
5,000	1	1	3.82	.43	4.25	2,825	1,455	1,445	1,360		7,085	1,124
10,000	1	2	5.72	.57	6.29	2,825	1,539	2,890	1,360	825	9,439	1,485
15,000	1	2	5.72	.67	6.39	2,825	1,623	4,335	1,360	1,070	11,213	1,769
20,000	2	3	9.54	.76	10.30	2,825	1,707	5,780	1,360	1,070	12,742	2,022
25,000	2	4	11.45	1.33	12.78	5,650	2,191[g/]	7,225	2,720	1,895	23,281	3,028
30,000	2	4	11.45	1.48	12.93	5,650	2,275[g/]	8,670	2,720	2,140	25,055	3,312

a/ Labor standards (crates per hour): dump, manual--350; dump, mechanical--1,200; set off empty crates--525.

b/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

c/ Hourly wage, $1.80.

d/ Base wage plus 6 per cent to cover Social Security, State Unemployment, and paid holidays.

e/ Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

f/ Includes labor, power, and variable repairs.

g/ Cost of crate interchanger used in five- and six-inspection belt plants is included.

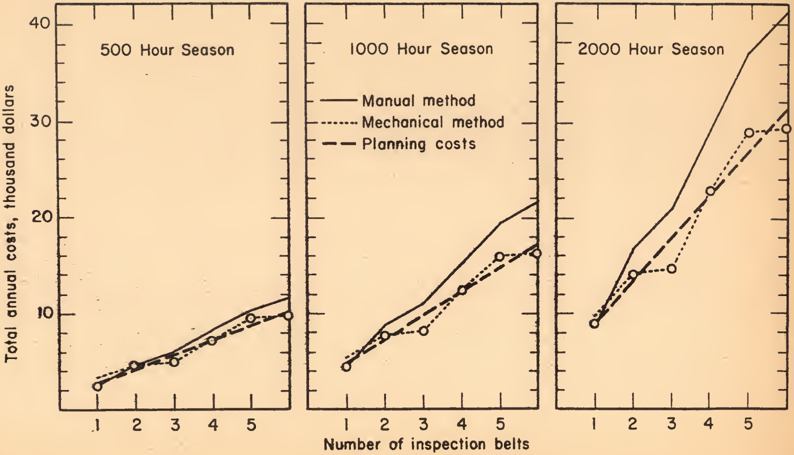

Figure 5. Total Annual Costs of the Dumping Stage in Plants Processing Strawberries for Freezing in Relation to Method Used, Size of Plant, and Length of Operating Season, California, 1958

are possible in two-belt plants operating more than 500 hours annually, and substantial savings can be obtained in still larger plants. Potential savings increase as length of operating season increases.

In addition to total season costs with particular methods, Figure 5 gives the more generalized cost relationship represented by the heavy, dashed cost line. This line shows the relation of total season cost to size of plant under the assumption that plants of any given size are equipped with the least-cost method and operate efficiently with this method. It is obtained by "smoothing" a line through the least-cost points at selected output rates--the circled points in the diagram--for the alternative dumping methods considered.[1] Costs in relation to dumping rate as represented by this line are referred to as "planning costs" since they represent attainable levels of efficiency and cost with respect to plant size.

A useful generalization of the "planning cost" relationships illustrated for the dumping stage in Figure 5 is the following equation--called the "planning equation"--which relates total season cost of the dumping stage to berry input rate (plant size) and hours operated per season.

$$TSC = 111 + 197.2(H) + 108.8(I) + 38.9(H)(I)$$

where

TSC = Total season cost of dumping (in dollars)
H = Hundred hours of plant operation per season
I = Thousand pounds of hourly plant raw product capacity.

The above equation can be used to estimate total season costs of the dumping stage in a plant of given size operating a given number of hours per season. For instance, if a plant is to operate 800 hours at a dumping rate of 10,000 pounds per hour, the estimated cost of the dumping stage, using the above equation is

$$TSC = 111 + (197.2)(8) + (108.8)(10) + (38.9)(8)(10) = \$5,889.$$

In the following sections planning equations for other cost components are similarly developed, and these are later brought together to form planning cost equations for an entire plant.

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[1] While the circled points in Figure 5 represent estimated costs based on Table 1, some variation about such points would occur in actual plant operations. The smoothed cost line shows "on the average" the relation of costs to rate of output. This simplification is found useful in later developments in this report.

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Quality Sort and Size Grade

There are two basic equipment arrangements in this stage. In one of these, size grading precedes the quality sort while in the other the order is reversed. Since this study detected no cost advantage for either method, only the cost of the quality sort prior to size grading, the more common method, is presented here.

Berries are deposited on quality-sort belts from the shaker-washers of the dumping stage. These belts, with few exceptions, are 30 inches wide and 25 to 30 feet long with an incline of 3 to 5 feet. Workers stationed along each side of the belt discard rots (overripe berries and those otherwise unfit for freezing) and divert sortouts (primarily underripe berries but including other minor defects) to the sortout filling station.

The sorted berries move either directly from the sorting belt into a cable or sieve size grader or are conveyed or flumed to the grader where they can be divided into three or more sizes. From the grader they enter the slicing and sugar stage or the whole berry filling stage.

Quality-sort labor is the major cost of this stage. The amount of sorting labor required depends upon both sorting rate and per cent of the raw product that must be removed from the inspection belt. Berry quality varies throughout the season and from year to year, necessitating adjustment of the number of sorters used for most efficient operation.

Since sorting labor represents a large share of the total cost of processing strawberries, a detailed analysis was made to determine the number of sorters required under various conditions. Simply observing good fruit with the objective of finding and removing defective fruit which may be present requires effort which cannot be measured through ordinary time and production studies. For this reason plant record data, supplemented by studies of labor usage and total quantities of strawberries dumped to the inspection belts and removed as sortouts and rots, were utilized to obtain sorting labor standards. An average of the amount of labor actually used, including the most inefficient as well as the efficient performances, would represent only an average output rather than a reasonably efficient performance which the labor production standards of this study are designed to represent. For this reason the least efficient half of the performances in each plant was discarded before calculating the job standard.

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It was found that sorting labor requirements vary somewhat with grade of berries being packed, but that sorting for Grade A, sliced, and Grade B, whole, are of approximately equal difficulty and, for given rates of product flow, require the same numbers of sorters. Since most of the berries frozen are of these grades, data presented in this report on the cost of sorting relate primarily to them. Figure 6 shows the number of workers required with respect to quantity of berries dumped and per cent of those berries which must be removed from the inspection belt--sortouts and rots--to pack the above grades. From this figure it can be found, for instance, that when 5,000 pounds per hour are dumped to the inspection belt and 15 per cent of the berries must be removed by sorting labor, 9.8--in round numbers 10--sorters are required. Likewise, where 5,000 pounds are dumped and the percentage of sortouts and rots is 10, 9 sorters are required; or if the percentage is 20, 12 sorters are needed.

While devised to indicate sorting labor requirements for Grade A sliced or Grade B whole berries, readings from Figure 6 can be adjusted to give sorting labor requirements of other grades. To obtain labor requirements for Grade A whole berries, it is necessary to add one additional hour of sorting labor to the amounts read from the chart for every 100 pounds of sortouts and rots removed from the inspection belt. Six-tenths hour less of sorter labor is required for every 100 pounds of sortouts and rots removed from the inspection belt when packing Grade B, sliced.

The equipment requirements of this stage consist of quality-sort belts, conveyors, and size graders. To determine capacity requirements of equipment to be used in conjunction with inspection belts--both in this and other stages--it was necessary to determine inspection belt capacity. This was done as a part of the sorting labor study. The average quantity run per hour during this study was found to be 4,200 pounds. With approximately 65 per cent of the observations, the rates ranged between 3,000 and 6,000 pounds per hour, and with 70 per cent of the observations, the observed rate was less than 5,000 pounds. Since most of the observations were at or just below 5,000 pounds per hour, this is taken as a reasonable estimate of belt capacity.

Table 2 gives the information needed to determine total season costs of this stage. The upper section of the table gives equipment replacement costs for plants having one to five inspection belts. The lower section shows the annual fixed charge and hourly variable charge for equipment and the labor charge at several percentages of sortouts plus rots.

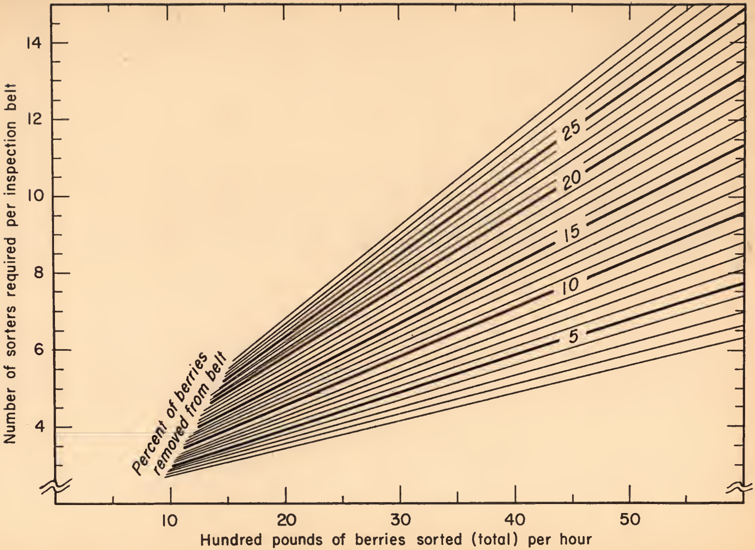

Figure 6. Number of Sorters Required Per Inspection Belt with Respect to Total Quantity of Berries Sorted and Per Cent of Berries Removed from the Belt by Inspection Labor when Packing Grade A, Sliced, or Grade B Whole Strawberries,[a] California, 1958

[a] To estimate sorter requirements for packing Grade A whole berries, add one sorter to the reading of this chart for each 100 pounds of rots and sortouts (100 pounds sorted times per cent removed). To estimate for Grade B sliced berries, subtract six tenths sorter for each 100 pounds of rots and sortouts.

TABLE 2

Equipment Total, Annual Fixed, and Hourly Variable Costs at Selected Capacity Operating Rates and Hourly Labor Costs at Selected Operating Rates and Percentages of Sortouts Plus Rots California, 1958

Number of quality sort belts	Raw product capacity	Equipment replacement costs[a]				Total equipment cost
		Quality sort belt[b]	Conveyor (sort belt to grader)	Size grader	Sortout section	
	pounds per hour	dollars				
1	5,000	2,050	c/	1,310	1,018	4,378
2	10,000	4,100	565	1,310	1,138	7,113
3	15,000	6,150	712	2,245	1,259	10,366
4	20,000	8,200	859	2,245	1,380	12,684
5	25,000	10,250	1,277	3,555	1,500	16,582

Number of quality sort belts	Raw product capacity	Equipment		Hourly sorting labor cost[e] at various levels of sortouts plus rots			
		Annual fixed charge[a]	Hourly variable charge[d]	Per cent			
				5	10	15	20
		dollars					
1	5,000	620	.29	12.17	15.65	17.38	20.86
2	10,000	980	.49	24.34	31.29	34.77	41.72
3	15,000	1,433	.71	36.51	46.94	52.15	62.58
4	20,000	1,745	.87	48.68	62.58	69.54	83.44
5	25,000	2,302	1.14	60.84	78.23	86.92	104.31

a/ See Appendix Table B for itemized list of equipment replacement costs and annual fixed charges.

b/ Includes fluorescent lighting over belts.

c/ This equipment not required in a one-belt plant.

d/ Includes charges for power and variable repairs and maintenance. Electric power calculated at 2.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

e/ Calculated at wage rate of $1.64 per hour plus 6 per cent to cover Social Security, State Unemployment, and paid holidays.

With the data on annual fixed costs and variable costs per hour given in Table 2, total season costs can be computed. Such cost estimates, supplemented with similar calculations for berry-input rates lying between belt capacity rates, are represented graphically in Figure 7 by the lightly drawn, broken lines which show the relation of total cost to rate of berry input with three different lengths of season and four different percentages of berry removal by the sorters.

As with the dumping stage, "planning costs" for given lengths of season and percentages of berry removal are shown by the heavy dashed lines. Each such line shows, for the hours operated per season and percentage of berry removal specified, season total costs with efficient operation in relation to berry-input rate. The cost relationships given in Figure 7 can be conveniently expressed in a "planning equation" as follows:

$$TSC = 343 + 190(H) + 85.6(I) + 186.8(H)(I) + 10.43(H)(I)(Q)$$

where

TSC = Total season cost (in dollars) of the quality-sort and size-grade stage
H = Hundred hours of quality-sort and size-grade operation per year
I = Thousand pounds per hour of quality-sort and size-grade capacity
Q = Per cent of berries removed from inspection belt--pounds removed divided by pounds dumped (100).

Slicing and Sugar System

The link between the sorting and grading stage and the sliced berry filling stage consists of moving the berries between stages, slicing them, and adding and mixing sugar with the berries. Only one portion of this stage, supply of sugar to the metering and mixing equipment, is affected by variation in method. For this reason the costs of sugar supply and of the remainder of the stage are divided and presented separately here.

Slicing and Sugar Mixing

This is a mechanical operation requiring no direct labor. The berries are deposited on a conveyor after grading and move to the slicer. Automatic sugar metering and mixing equipment then combines berries and sugar in the desired proportion and the berries enter the filling stage. This equipment

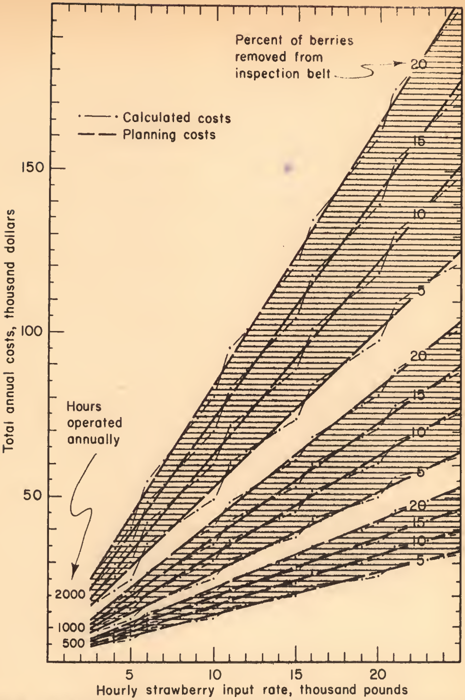

Figure 7. Total Annual Costs of the Quality-Sort and Size-Grade Stage of Plants Processing Strawberries for Freezing with Respect to Hourly Strawberry-Input Rate, Berry Quality, and Length of Operating Season when Packing Grade A, Sliced, or Grade B Whole Strawberries,[a] California, 1958

[a] To estimate quality-sort and size-grade costs for packing Grade A whole strawberries, add \$17.40 to the reading of this chart for each 1,000 pounds of rots and sortouts removed from the inspection belt (hourly input rate times hours operated annually times per cent removed). To estimate for Grade B sliced strawberries, subtract \$10.50 for each 1,000 pounds of rots and sortouts removed.

must be of sufficient capacity to handle the maximum output of the plant as determined by inspection belt capacity and minimum berry removal, resulting in an unavoidable undercapacity operation of berry slicing and sugar mixing equipment during most of the season. There are many alternatives in equipment and equipment arrangements which would satisfy the requirements of this operation. Thus, while there would be a best arrangement for each plant, there is no single arrangement which would be best for all plants. The differences are relatively small, however, and the equipment chosen is a representative combination that gives a practical basis for cost estimation. The equipment units required and their replacement, annual fixed, and hourly variable costs are given for plants of different berry-input capacity rates in Table 3.

Sugar Supply

There are two methods of supplying sugar to the metering and mixing equipment. The first of these requires practically no equipment but uses a large amount of labor and is referred to here as the "manual" method. The other is almost completely automatic, requiring only a nominal amount of labor so is called the "mechanical" method.

In the manual method, bagged sugar is kept in supply at the sugar station by fork-lift truck which delivers approximately 25 bags per trip. The bagged sugar is then manually dumped into a hopper over the sugar meter. This involves obtaining the bags of sugar from a near-by pallet, opening them, emptying the sugar into a hopper, and folding and stacking the empty bag. A labor standard of 1,500 pounds of sugar per man-hour applies to this job.

The mechanical method uses bulk sugar which is delivered to the plant by tank truck and placed in a silo or storage bin. It is taken from this bin by gravity and/or power conveyor and moved as needed to point of use.

Table 4 shows the replacement, fixed, and variable costs of these sugar supply methods for five plant sizes as determined by number of quality inspection belts. Calculations for the manual system in this table are based on the most commonly used berry-sugar ratio--4 to 1--and 5 per cent of cull berries (rots). A smaller sugar ratio or greater per cent of culls would decrease the variable cost of the manual system operation while more sugar or less culls would increase this cost. Such variations, however, do

TABLE 3

Replacement, Annual Fixed, and Hourly Variable Equipment Costs for Slicing and Sugar Mixing with Respect to Plant-Input Capacity in Plants Processing Strawberries for Freezing, California, 1958

Plant-input capacity	Equipment replacement cost[a]			Annual fixed charge[a]	Hourly variable cost[b]
	Conveyor, grader to slicer	Slicer	Mixer with sugar feed and control		
pounds per hour	dollars				
5,000	560	910	1,880	534	0.21
10,000	560	910	2,380	617	0.23
15,000	560	910	2,880	699	0.30
20,000	1,120	1,820	4,760	1,233	0.47
25,000	1,120	1,820	5,260	1,316	0.50

a/ See Appendix Table B for itemized list of equipment replacement costs and annual fixed charges.

b/ Includes charges for power and variable repairs and maintenance. Electrical power estimated at 2.5 cents per horsepower hour. Variable repairs and maintenance estimated at 0.5 per cent of replacement cost per 100 operating hours.

TABLE 4

Total Season Costs of the Sugar Supply System with Respect to Plant-Input Capacity in Plants Processing Strawberries for Freezing, California, 1958

Item	Number of quality inspection belts				
	1	2	3	4	5
	pounds				
Capacity (berry input per hour)	5,000	10,000	15,000	20,000	25,000
Sugar supplied per hour[a]	1,188	2,375	3,563	4,750	5,938
	Manual system				
	dollars				
Equipment replacement cost	100.	200.	300.	400.	500.
Annual fixed charge[b]	17.	33.	50.	66.	83.
Variable repairs and maintenance per 100 hours[c]	0.50	1.	1.50	2.00	2.50
Labor cost per 100 hours[d]	191.	382.	572.	764.	764.
Total season cost:					
500-hour season	973.	1,946.	2,919.	3,895.	3,914.
1,000-hour season	1,930.	3,859.	5,789.	7,723.	7,745.
2,000-hour season	3,843.	7,685.	11,528.	15,380.	15,407.
	Mechanical system				
Equipment replacement cost	6,500.	10,000.	13,500.	17,000.	20,500.
Annual fixed charge[b]	1,073.	1,650.	2,228.	2,805.	3,383.
Variable repairs and maintenance per 100 hours[c]	33.	50.	68.	85.	103.
Power cost per 100 hours[e]	2.50	3.75	5.00	6.25	7.50
Total season cost:					
500-hour season	1,251.	1,919.	2,593.	3,261.	3,936.
1,000-hour season	1,428.	2,188.	2,958.	3,718.	4,488.
2,000-hour season	1,783.	2,725.	3,688.	4,630.	5,593.

a/ Estimated on the basis of 5 per cent rots and 4 to 1 berry-sugar ratio.

b/ Based on replacement cost of equipment. Includes allowances for depreciation, 10 per cent; taxes, 1 per cent; insurance, 1 per cent; fixed repairs, 1.5 per cent; and interest, 3 per cent (approximately 5.5 per cent on undepreciated balance).

c/ Estimated as 0.5 per cent of replacement cost of equipment.

d/ Hourly wage rate: $1.80 plus 6 per cent to allow for Social Security, State Unemployment, and paid holidays. Labor standard: 1,500 pounds of sugar per hour.

e/ Calculated on the basis of 2.5 cents per hour per motor horsepower.

not affect the total annual cost of operation of a mechanical system. From the table it can be seen that the fixed costs of the manual method are low and variable costs are high, while the reverse holds for the mechanical method. The total annual costs given in this table show that only in the very small plant operating an unusually short season does the manual method result in lowest total seasonal cost of operation. Since bulk sugar has been consistently priced at 15 cents per hundredweight below bagged sugar, even this limited area of advantage of the manual method is eliminated. Therefore, all following cost relationships given for this stage are based on use of the mechanical method.

Total Cost of the Slicing and Sugar System

The total annual cost of the slicing and sugar system is a combination of the costs of the sugar supply and slicing and sugar mixing system. These costs can be computed from the annual fixed costs and hourly variable costs given in Tables 3 and 4. They are shown in Figures 8 and 9 by the lightly drawn, broken line. While cost calculations for these figures are made at 1,000-pound intervals in rate of berry input, total costs increase only at 5,000-pound intervals. This is due to plant design whereby equipment capacity throughout this stage is furnished to handle peak loads as determined by the number of quality inspection belts. Annual fixed charge on this equipment does not vary with quantity of berries processed up to its capacity. Since no direct labor is involved, the variable costs are entirely due to equipment; and these costs, too, are the same whether the equipment is used at or below its capacity.

As in the preceding stage cost analysis, the planning costs of this stage are shown by the heavy, dashed lines of Figures 8 and 9 and are given by the following planning equations:

Slicing and sugar mixing

$$TSC = 335 + 14(H) + 44(I) + 1.6(H)(I)$$

where

TSC = Total season cost (in dollars) of slicing and sugar mixing
H = Hundred hours of slicing and sugar mixing operation per year
I = Thousand pounds per hour of slicing and sugar mixing capacity.

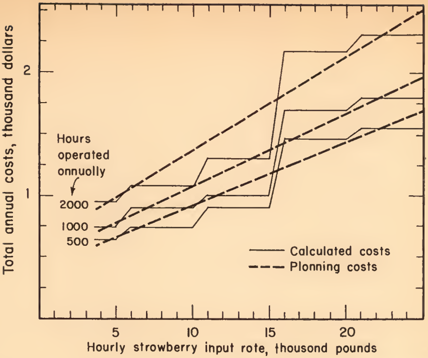

Figure 8. Total Annual Cost of the Slicing and Sugar Mixing Stage in Plants Processing Strawberries for Freezing with Respect to Hourly Strawberry-Input Rate and Length of Operating Season California, 1958

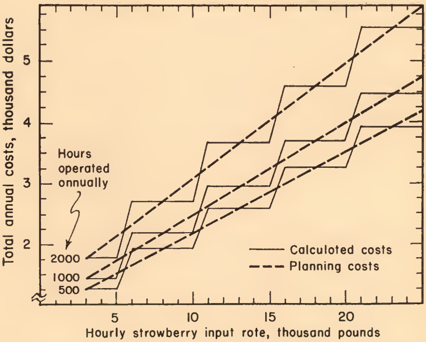

Figure 9. Total Annual Cost of the Sugar Supply System in Plants Processing Strawberries for Freezing with Respect to Hourly Strawberry-Input Rate and Length of Operating Season California, 1958

Sugar supply

$$TSC = 784 + 26(H) + 115(I) + 3.6(H)(I)$$

where

TSC = Total season cost (in dollars) of the sugar supply system
H = Hundred hours of sugar supply system operation per year
I = Thousand pounds of strawberry capacity of sugar supply system per hour.

Filling

The methods used in the container-filling stage vary from a highly mechanized operation with 10- and 16-ounce cartons to little mechanization in filling 30-pound tins. While the filling methods are dissimilar for different containers, for particular containers they are very similar among different plants. This is one of the high-cost stages in strawberry processing plants, but there are few apparent opportunities to reduce those costs.

Cartons, 10 and 16 Ounce

The same equipment and crew can be used to fill 10- or 16-ounce cartons. Although filling costs per case of 24 cartons differ slightly because of small differences in output rate for given crews and equipment, they are so similar that a detailed cost analysis is shown for only the 10-ounce cartons.

In the basic method of carton filling, cartons are fed to automatic fillers from which the filled cartons are conveyed to a closer. The closer places a lid on the carton and discharges it to a conveyor on which it is moved to the casing station. This process is highly standardized among different plants except for alternative procedures in feeding cartons to the filler. With one procedure--method A--the cartons are placed in an upright position on a short conveyor leading directly into the filler. With method B, a mechanical device, generally called a bag unloader, is used in which cartons are stacked several layers high and from which they are automatically discharged to a chute which leads into the filler. When using method A, the carton-feed worker usually transfers six cartons at a time from the carton bag to the filler. The bag unloader of method B enables the worker to handle approximately twice this number of cartons at a time. Method A carton-feed workers are stationed at the filler while in method B they are located on a mezzanine to allow gravity feed through a chute to the filler.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Filling capacity is determined by the type and number of fillers. Two types of fillers are considered in this report. One is a low-speed filler with a capacity of approximately 110 cartons per minute, and the other is a high-speed filler with a capacity of approximately 220 cartons per minute. One closer is adequate for use with each low-speed filler, but two closers are required to handle the output of each high-speed filler.

Ten-Ounce Cartons.--Filling crew requirements, determined from the work standards for individual jobs, and the rate of filling are shown in Table 5 for output rates of 100 to 1,500 cases of 10-ounce cartons per hour. This table also gives the equipment replacement costs, annual fixed charges, and hourly variable costs. It can be seen from the table that, while mechanical aids to carton feeding increase fixed costs, they also decrease hourly labor cost at most output rates.

Total season costs, computed at 100-case intervals in output rate from information given in Table 5, are shown in Figure 10 for three lengths of season. From this figure it can be seen that total season costs are nearly equal for these methods at low-output rates and short seasons. Method B, as is frequently true in the case of manual versus mechanical techniques, becomes the lower cost method at higher rates of output and for long seasons.

Planning costs for filling 10-ounce cartons are given by the heavy dashed lines of Figure 10 and by the following equation:

$$TSC = 488 + 355(h) + 587(P) + 83.3(h)(P)$$

where

TSC = Total season cost (in dollars) of filling 10-ounce cartons
h = Hundred hours per year of 10-ounce carton filling
P = Thousand pounds per hour of 10-ounce carton filling capacity.[1]

Sixteen-Ounce Cartons.--The costs per case for filling 16-ounce and 10-ounce cartons are nearly the same. For that reason the detailed cost analysis for 16-ounce cartons, as given for 10-ounce cartons in Table 5 and Figure 10,

---

[1] Filling and casing labor and equipment production standards have been established in cases (or tins) per hour, and the analysis is presented on this basis for convenience and because of general familiarity with measurement of labor and equipment output in these terms. However, these costs are presented on the basis of 1,000 pounds per hour in this and in all other planning equations to facilitate comparison of costs of the various products and future combination of planning equations of all of the plant cost components to arrive at total plant costs.

TABLE 5

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Filling 10-Ounce Cartons, 24 Cartons Per Case, with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (cases per hour)	Workers required[a]			Variable costs per hour			Equipment replacement costs and annual fixed charge[b]							
	Feed cartons[c]	Operate equipment[d]	Supply cartons[d]	Labor[e]	Power and repair[f]	Total[g]	Bag stand	Bag unloader with carton run	Filler	Carton conveyors (filler to seamer)	Carton conveyors (seamer to "case in")	Total replacement cost	Annual carton closer rental	Annual fixed charge[h]
	number			dollars										
	Without mechanical carton-feeding aids													
100	1	1	1	5.55	0.29	5.84	50		4,010		765	4,825	950	1,721
200	2	1	1	7.29	0.29	7.58	50		4,010		765	4,825	950	1,721
300	2	1	1	7.29	0.55	7.84	100		7,120	745	765	8,730	1,900	3,287
400	3	2	1	10.94	0.55	11.49	100		7,120	745	765	8,730	1,900	3,287
500	3	2	1	10.94	0.84	11.78	150		11,130	745	1,530	13,555	2,850	5,006
600	4	2	1	12.68	0.84	13.52	150		11,130	745	1,530	13,555	2,850	5,006
700	4	2	1	12.68	1.10	13.78	200		14,240	1,490	1,530	17,460	3,800	6,574
800	5	3	2	18.23	1.10	19.33	200		14,240	1,490	1,530	17,460	3,800	6,574
900	5	3	2	18.23	1.36	19.59	250		18,250	1,490	2,295	22,285	4,750	8,293
1,000	6	3	2	19.97	1.36	21.33	250		18,250	1,490	2,295	22,285	4,750	8,293
1,100	6	3	2	19.97	1.62	21.59	300		21,360	2,235	2,295	26,190	5,700	9,861
1,200	7	4	2	23.62	1.62	25.24	300		21,360	2,235	2,295	26,190	5,700	9,861
1,300	8	4	2	25.36	1.94	27.30	350		25,370	2,235	3,060	31,015	6,650	11,579
1,400	8	4	2	25.36	1.94	27.30	350		25,370	2,235	3,060	31,015	6,650	11,579
1,500	9	4	2	27.09	2.20	29.29	400		28,480	2,980	3,060	34,920	7,600	13,147
	With mechanical carton-feeding aids													
100	1	1	1	5.55	0.37	5.92	50	1,380	4,010		765	6,205	950	1,937
200	1	1	1	5.55	0.37	5.92	50	1,380	4,010		765	6,205	950	1,937
300	2	1	1	7.29	0.63	7.92	50	1,380	7,120	745	765	10,060	1,900	3,498
400	2	1	1	7.29	0.63	7.92	50	1,380	7,120	745	765	10,060	1,900	3,498
500	2	1	1	7.29	1.00	8.29	100	2,760	11,130	745	1,530	16,265	2,850	5,434
600	3	2	1	10.94	1.00	11.94	100	2,760	11,130	745	1,530	16,265	2,850	5,434
700	3	2	1	10.94	1.26	12.20	100	2,760	14,240	1,490	1,530	20,120	3,800	6,996
800	3	2	2	12.85	1.26	14.11	100	2,760	14,240	1,490	1,530	20,120	3,800	6,996
900	4	2	2	14.59	1.60	16.19	150	4,140	18,250	1,490	2,295	26,325	4,750	8,932
1,000	4	2	2	14.59	1.60	16.19	150	4,140	18,250	1,490	2,295	26,325	4,750	8,932
1,100	4	3	2	16.49	1.86	18.35	150	4,140	21,360	2,235	2,295	30,180	5,700	10,494
1,200	5	3	2	18.23	1.86	20.09	150	4,140	21,360	2,235	2,295	30,180	5,700	10,494
1,300	5	3	2	18.23	2.25	20.48	200	5,520	25,370	2,235	3,060	36,385	6,650	12,430
1,400	5	3	2	18.23	2.25	20.48	200	5,520	25,370	2,235	3,060	36,385	6,650	12,430
1,500	6	3	2	19.97	2.51	22.48	200	5,520	28,480	2,980	3,060	40,240	7,600	13,993

[a] Labor standards (cases per hour): feed cartons, without mechanical aids--185; feed cartons, with mechanical aids--280; operate equipment--one worker per filling line; supply cartons--750.

[b] See Appendix Table B for list of equipment replacement costs and annual fixed charges.

[c] Hourly wage, $1.64.

[d] Hourly wage, $1.80.

[e] Base wage plus 6 per cent to cover F.I.C.A., State Unemployment, and paid holidays.

[f] Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

[g] Includes labor, power, and variable repairs.

[h] The annual fixed charge in this table includes carton closer rental.

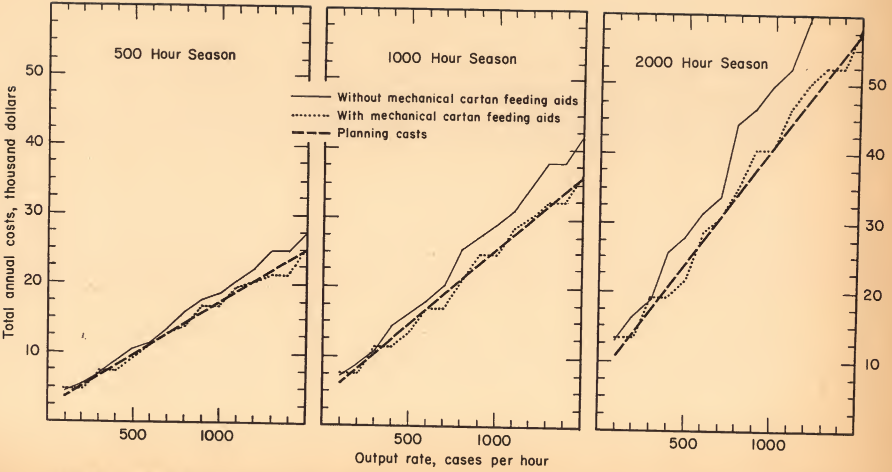

Figure 10. Total Annual Cost of Filling 10-Ounce Cartons, 24 Per Case, in Plants Processing Strawberries for Freezing in Relation to Method Used, Length of Operating Season, and Hourly Output Rate, California, 1958

is not presented here. However, the following planning cost equation has been developed from an analysis of 16-ounce carton filling similar to that given for 10-ounce cartons.

$$TSC = 488 + 332(h) + 367(P) + 55.7(h)(P)$$

where

TSC = Total season cost (in dollars) of filling 16-ounce cartons
h = Hundred hours per year of 16-ounce carton filling
P = Thousand pounds per hour of 16-ounce carton filling capacity.[1]

Although the costs per case are nearly the same for 16-ounce as for 10-ounce cartons, they differ substantially on a poundage basis due to difference in weight per case. For instance, if a plant were to fill 10-ounce cartons at a rate of 10,000 pounds per hour for 1,200 hours per year, its annual filling costs would be:

$$TSC = 488 + 335(12) + 587(10) + 83.3(12)(10) = \$20{,}374,$$

and if packed under the same conditions with the exception of using 16-ounce rather than 10-ounce cartons, its costs would be:

$$TSC = 488 + 332(12) + 367(10) + 55.7(12)(10) = \$14{,}826.$$

Tins, 6½ Pound

Of the containers considered in this report, 6½-pound tins represent the smallest proportion of the California strawberry pack. The same filling method, with one exception, was used for this container in all of the plants studied. Since the exception was a comparatively high-cost operation at all output rates, and to avoid disclosure of individual plant costs, only the standard method is presented here. This is similar to method A of the 10-ounce and 16-ounce cartons. The tins are placed usually two at a time on a short conveyor to the filler where they are automatically filled and transferred to the closer. From the closer they are either conveyed or roll down an inclined chute to the casing station. One closer is used in conjunction with each filler, and two workers are required--one to feed tins to the filler and the other to operate the equipment. Filler capacity is estimated at 200 cases of six tins each per hour.

Table 6 gives the crew requirements, variable costs, and fixed charges for output rates of 50 to 300 cases per hour. Total annual filling costs,

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[1] See footnote on p. 26.

[illegible]

$$[illegible]$$

where

[illegible]

[illegible]

$$[illegible]$$

[illegible]

$$[illegible]$$

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 6

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Filling 6½-Pound Tins, 6 Tins Per Case, with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (cases per hour)	Workers required[a]		Variable costs per hour			Equipment replacement costs and annual fixed charge[b]				
	Feed tins[c]	Operate equipment[d]	Labor[e]	Power and repair[f]	Total[g]	Filler	Closer	Conveyor (seamer to "case in")	Total investment	Annual fixed charge
	number		dollars							
50	1	1	3.65	.76	4.41	8,125	5,005	765	13,895	2,267
100	1	1	3.65	.76	4.41	8,125	5,005	765	13,895	2,267
150	1	1	3.65	.76	4.41	8,125	5,005	765	13,895	2,267
200	1	1	3.65	.76	4.41	8,125	5,005	765	13,895	2,267
250	2	2	7.29	1.52	8.81	16,250	10,010	1,530	27,790	4,534
300	2	2	7.29	1.52	8.81	16,250	10,010	1,530	27,790	4,534

a/ Labor standards: feed tins--200 cases per hour; operate equipment--one worker per fill line.

b/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

c/ Hourly wage, $1.64.

d/ Hourly wage, $1.80.

e/ Base wage plus 6 per cent to cover F.I.C.A., State Unemployment, and paid holidays.

f/ Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

g/ Includes labor, power, and variable repairs.

computed from the information given in Table 6, are shown for 100-, 300-, and 500-hour seasons by the lightly drawn lines of Figure 11. Shorter operating seasons are considered in these cost calculations as compared with the cost calculations for cartons because the $6\frac{1}{2}$-pound tins generally are filled during only a fraction of the total time the plant is in operation. The planning costs for filling $6\frac{1}{2}$-pound tins, as shown by the dashed lines of Figure 11, are represented by the following equation:

$$TSC = 1{,}133 + 221(h) + 291(P) + 56.4(h)(P)$$

where

TSC = Total season cost (in dollars) of filling $6\frac{1}{2}$-pound tins
h = Hundred hours per year of $6\frac{1}{2}$-pound tin filling operation
P = Thousand pounds per hour of $6\frac{1}{2}$-pound tin filling capacity.[1]

Tins, 30 Pound

Sliced Strawberries.--Sliced berry filling in 30-pound tins is usually a diversion or overflow operation from the consumer-size filling lines. It is a simple operation with practically no variation in method. Sliced and sugared berries flow into a fill hopper from the mixer. The fill worker takes an empty tin from an adjacent stack or from a chute, places it on a scale which is under a spout on the hopper, fills it by opening and closing the spout, places a lid on the tin, and pushes it aside on a conveyor to the set-off station. The tins are moved from the conveyor to pallets by a set-off worker. The lid is often placed on the tin by the set-off worker rather than by the fill worker, but this has no effect on filling costs.

Equipment replacements costs, annual fixed charges, and variable costs of filling this product are given in the bottom section of Table 7. Total

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[1] See footnote on p. 26.

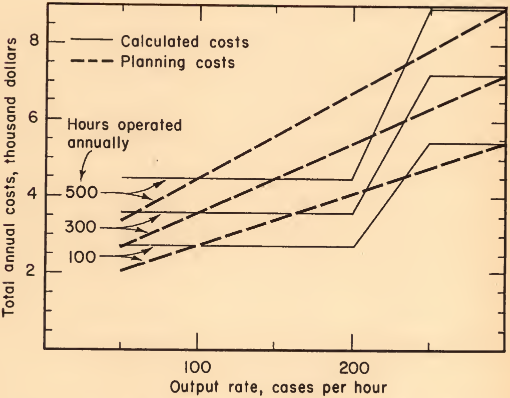

Figure 11. Total Annual Costs of Filling $6\frac{1}{2}$-Pound Tins, 6 Per Case, in Plants Processing Strawberries for Freezing with Respect to Length of Operating Season and Hourly Output Rate
California, 1958

TABLE 7

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Filling 30-Pound Tins with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (tins per hour)	Workers required[a/]				Variable costs per hour			Equipment replacement cost and annual fixed charge[b/]					
	Stamp tin[c/]	Fill tin[d/]	Add sugar[c/]	Set off[d/]	Labor[e/]	Power and repair[f/]	Total[g/]	Fill hopper without sugar meter	Mixing screw with sugar control and fill hopper	Scale	Conveyor (steel roller)	Total replacement cost	Annual fixed charge
	number				dollars								
	Whole berries--sugar manually added												
50	h/	1	1	1	5.55	.03	5.58	200		260	75	535	77
100	1	1	1	1	7.29	.03	7.32	200		260	75	535	77
150	1	2	2	1	10.94	.05	10.99	400		520	150	1,070	154
200	1	2	2	2	12.85	.05	12.90	400		520	150	1,070	154
250	2	2	2	2	14.59	.05	14.64	400		520	150	1,070	154
300	2	3	3	2	18.23	.08	18.31	600		780	225	1,605	231
	Whole berries--sugar mechanically added												
50	h/	1		1	3.82	.10	3.92		1,315	260	75	1,650	261
100	1	1		1	5.55	.10	5.65		1,315	260	75	1,650	261
150	1	2		1	7.46	.12	7.58		1,515	520	150	2,185	338
200	1	2		2	9.37	.12	9.49		1,515	520	150	2,185	338
250	2	2		2	11.11	.12	11.23		1,515	520	150	2,185	338
300	2	3		2	13.02	.16	13.18		1,715	780	225	2,720	415
	Sliced berries--sugar mechanically added												
50	h/	1		1	3.82	.03	3.85	200		260	75	535	77
100	1	1		1	5.55	.03	5.58	200		260	75	535	77
150	1	1		1	5.55	.03	5.58	200		260	75	535	77
200	1	2		2	9.37	.05	9.42	400		520	150	1,070	154
250	2	2		2	11.11	.05	11.16	400		520	150	1,070	154
300	2	2		2	11.11	.05	11.16	400		520	150	1,070	154

a/ Labor standards (tins per hour): stamp tin--220; fill tin, whole berries--140; fill tin, sliced berries--155; add sugar, whole berries--140; set off--165.

b/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

c/ Hourly wage, $1.64.

d/ Hourly wage, $1.80.

e/ Base wage plus 6 per cent to cover Social Security, State Unemployment, and paid holidays.

f/ Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

g/ Includes labor, power, and variable repairs.

h/ Job performed by "fill tin" or "set off" worker.

annual costs, computed at 50-tin intervals in output rate from the information given in Table 7, are shown by the lightly drawn lines of Figure 12. Planning costs shown by the heavy, dashed lines of Figure 12 are represented by the following equation:

$$TSC = 169 + 179(h) + 114(h)(P)$$

where

TSC = Total season cost (in dollars) of filling 30-pound tins of sliced strawberries
h = Hundred hours per year of 30-pound tins, sliced berry filling operation
P = Thousand pounds per hour of 30-pound tins, sliced berry filling capacity.[1]

Whole Strawberries.—The filling operation is practically the same for 30-pound tins of whole berries as for sliced berries. However, while sliced berry filling is closely integrated with filling lines for consumer-size cartons, whole berry filling is an independent operation. Although the same main sugar supply is used for both sliced and whole berries, separate labor and equipment must be supplied to combine sugar and whole berries in the proper proportion.

Sugar mixing equipment consisting of a meter and screw-type mixer which also serves as the conveyor from the size grader to the whole berry fill hopper is usually used for this operation. However, in some plants, sugar is manually rather than mechanically added to the berries to avoid investment in separate sugaring equipment for this item. When this method is used, an additional worker is required to work with each "fill" worker to add a measure of sugar to each tin as it is filled. Since sugar is often manually added to whole berries as a part of the filling operation, costs are computed with both the manual and mechanical sugaring methods to allow cost comparison.

Table 7 gives the crew requirements, equipment replacement costs, annual fixed charges, and variable costs of filling 30-pound tins of whole berries using the manual and mechanical sugaring methods. Total annual costs for 100-, 300-, and 500-hour seasons, computed at 50-tin intervals from the information given in Table 7, are shown for this product by the lightly drawn lines of Figure 13. Planning costs are shown by the heavy, dashed lines of Figure 13 and are given by the equation that follows.

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[1] See footnote on p. 26.

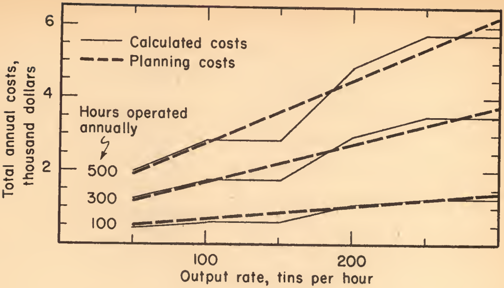

Figure 12. Total Annual Costs of Filling 30-Pound Tins of Sliced Strawberries in Plants Processing Strawberries for Freezing in Relation to Length of Operating Season and Hourly Output Rate California, 1958

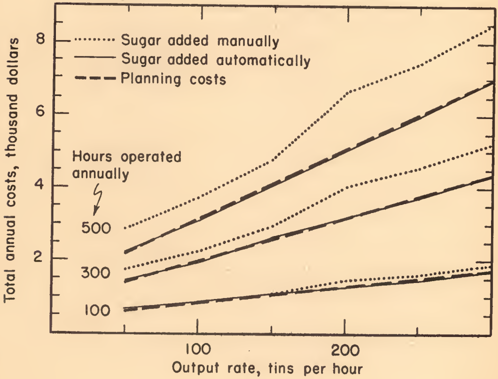

Figure 13. Total Annual Costs of Filling 30-Pound Tins of Whole Strawberries in Plants Processing Strawberries for Freezing in Relation to Method Used, Length of Operating Season, and Hourly Output Rate California, 1958

$$TSC = 204 + 205(h) + 22(P) + 123.1(h)(P)$$

where

TSC = Total season cost (in dollars) of filling 30-pound tins of whole berries
h = Hundred hours per year of 30-pound tins, whole berry filling operation
P = Thousand pounds per hour of 30-pound tins, whole berry filling capacity.1/

The 30-pound tin sliced berry and 30-pound tin whole berry filling costs given above are not comparable due to the omission of sugaring costs from the sliced berry calculations. To place these costs on the same basis, it is necessary only to add the slicing and sugar mixing costs as given in the slicing and sugar system stage to the sliced berry equation.

Casing

There are three casing methods generally used for carton casing in strawberry freezing plants. These were analyzed in relation to the quantities and costs of labor and equipment required at different output rates.

In the manual method, method A, there are four components. These are: (1) stencil, form, and staple case; (2) fill case; (3) manually seal case; and (4) set off. Workers for stenciling and forming the stapled-bottom case are stationed on a raised platform or mezzanine. The stenciling job consists of obtaining bundles of flat cartons from near-by temporary storage, placing them on a table and removing the twine binding, applying one stencil to each case, and moving the stenciled flat cases to a case-forming table. Flat cases are formed manually by the case former as he transfers them individually from the table to a power stapler. The bottom of the case is stapled and the case placed in a chute which leads to the casing area. A casing worker transfers the case from the chute to a filling station, takes four cartons at a time for the carton conveyor, and places them in the case. When filled, the case is pushed aside to the case-sealing and palletizing station. Here, a set-off worker receives the case, applies glue to the case flaps, usually with a 3" to 4" brush, and sets it aside to a pallet for transfer to the freezer. Pallets are stacked with layer dividers, generally consisting of six 1" x 4" to 2" x 3" slats, placed between every second layer to allow air circulation.

1/ See footnote on p. 26.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Method B eliminates the labor involved in the case stapling and manual sealing of method A through use of a nonstapled case and automatic case-sealing equipment. The components of this method are: (1) stencil and form case, (2) fill case, (3) mechanically seal case, and (4) set off. Stencil and case-form workers are stationed near the casing station where cases are stenciled as in method A. The flat case is then opened, the bottom flaps folded in, and the case inverted to flatten the bottom flaps and prepare the case for manual filling. The formed case is set aside to the casing conveyor or, if cases accumulate temporarily, to a stack of cases adjacent to the conveyor. The fill-case worker takes the case from this location and fills it as in method A. The case then passes through an automatic case sealer and compressor to the palletizing area. A set-off worker sets the case aside to a pallet as in method A.

In method C, the most mechanized method observed, the cartons are conveyed directly from the closer into a casing machine where they are mechanically filled. The components of this method are: (1) stencil case, (2) form case and operate casing machine, (3) mechanically seal, and (4) set off. The stencil and set-off components are the same as in method B. The casing machine and its operator, who forms the case, replace both the case-forming and case-filling workers. A case is formed in this method by opening the flat case, folding the bottom flaps down, and placing the case over a sleeve on the casing machine.

While the discussion of casing methods has been directed to carton casing up to this point, the descriptions of casing methods A and B also apply to 6½-pound tins with the exception that two tins rather than four cartons are generally transferred to the case at a time. Use of an automatic casing machine as described in method C was not observed in use for 6½-pound tins during this study.

Crew requirements, variable costs, and equipment replacement costs and annual fixed charges for output rates of 100 to 1,500 cases per hour of 10-ounce cartons, 24 per case, are given in Table 8. Similar tables are given in Appendix Tables D and E for 16-ounce cartons and 6½-pound tins. Total annual costs in relation to output per hour and length of season--calculated from the information contained in these tables--are shown in Figures 14 to 16. These graphs show that all methods are nearly equal in total seasonal cost at low rates of output for short seasons. However, method B becomes

TABLE 8

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Casing 10-Ounce Cartons, 24 Cartons Per Case, with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (cases per hour)	Workers required[a]				Variable costs per hour			Equipment replacement costs and annual fixed charge[b]						
	Stamp case[c]	Form case[c]	Fill case[c]	Set off[d]	Labor[e]	Power and repair[f]	Total[g]	Stapler	Casing machine	Sealer and compressor	Conveyors[h]	Miscellaneous[i]	Total replacement cost	Annual fixed charge[j]
	number				dollars									
	Method A--stapled case, manual filling, manual sealing													
100	[k]	1	1	1	5.38	.05	5.43	675			75	160	910	142
200	[k]	1	2	2	9.03	.05	9.08	675			75	160	910	142
300	1	2	2	2	12.51	.10	12.61	1,350			75	260	1,685	267
400	1	2	3	3	16.15	.10	16.25	1,350			75	260	1,685	267
500	1	2	3	3	16.15	.11	16.26	1,350			150	260	1,760	277
600	1	3	4	4	21.54	.15	21.69	2,025			150	360	2,535	401
700	1	3	4	4	21.54	.15	21.69	2,025			150	360	2,535	401
800	2	4	5	5	28.66	.20	28.86	2,025			150	520	2,695	422
900	2	4	5	5	28.66	.20	28.86	2,700			225	520	3,445	544
1,000	2	4	6	6	32.31	.20	32.51	2,700			225	520	3,445	544
1,100	2	5	6	6	34.05	.21	34.26	2,700			225	620	3,545	557
1,200	2	5	7	7	37.69	.24	37.93	3,375			225	620	4,220	668
1,300	2	5	8	7	39.43	.26	39.69	3,375			300	620	4,295	678
1,400	2	6	8	8	43.08	.30	43.38	4,050			300	721	5,070	803
1,500	3	6	9	8	46.56	.31	46.87	4,050			300	780	5,130	810
	Method B--nonstapled case, manual filling, mechanical sealing													
100	[k]	[k]	1	1	3.65	.30	3.95			5,295	75	85	5,455	895
200	[k]	[k]	2	1	5.38	.30	5.68			5,295	75	85	5,455	895
300	1	1	2	1	8.86	.30	9.16			5,295	75	85	5,455	895
400	1	2	3	2	14.25	.30	14.55			5,295	75	85	5,455	895
500	1	2	3	2	14.25	.59	14.84			10,590	150	110	10,850	1,782
600	1	2	4	2	15.98	.59	16.57			10,590	150	110	10,850	1,782
700	1	3	4	3	19.63	.59	20.22			10,590	150	110	10,850	1,782
800	2	3	5	3	23.11	.60	23.71			10,590	150	170	10,910	1,789
900	2	3	5	3	23.11	.89	24.00			15,885	225	195	16,305	2,676
1,000	2	4	6	3	26.58	.89	27.47			15,885	225	195	16,305	2,676
1,100	2	4	6	4	28.49	.89	29.38			15,885	225	195	16,305	2,676
1,200	2	4	7	4	30.23	.89	31.12			15,885	225	195	16,305	2,676
1,300	2	5	8	4	33.71	1.19	34.90			21,180	300	220	21,700	3,563
1,400	2	5	8	5	35.62	1.19	36.81			21,180	300	220	21,700	3,563
1,500	3	5	9	5	39.09	1.19	40.28			21,180	300	280	21,760	3,571
	Method C--nonstapled case, mechanical casing, mechanical sealing													
100	[k]	1		1	3.65	.63	4.29		6,485	5,295	75	85	11,940	1,965
200	[k]	1		1	3.65	.63	4.29		6,485	5,295	75	85	11,940	1,965
300	1	1		1	5.38	.63	6.02		6,485	5,295	75	85	11,940	1,965
400	1	1		2	7.29	.63	7.93		6,485	5,295	75	85	11,940	1,965
500	1	2		2	9.03	1.26	9.67		12,970	10,590	150	110	23,820	3,922
600	1	2		2	9.03	1.26	10.31		12,970	10,590	150	110	23,820	3,922
700	1	2		3	10.94	1.26	12.22		12,970	10,590	150	110	23,820	3,922
800	2	2		3	12.68	1.26	13.96		12,970	10,590	150	170	23,880	3,922
900	2	3		3	14.42	1.89	15.70		19,455	15,885	225	195	35,760	5,886
1,000	2	3		3	14.42	1.89	15.70		19,455	15,885	225	195	35,760	5,886
1,100	2	3		4	16.32	1.89	18.24		19,455	15,885	225	195	35,760	5,886
1,200	2	3		4	16.32	1.89	18.24		19,455	15,885	225	195	35,760	5,886
1,300	2	3		4	16.32	2.52	18.24		25,940	21,180	300	220	47,640	7,843
1,400	2	4		5	19.97	2.52	21.89		25,940	21,180	300	220	47,640	7,843
1,500	3	4		5	21.71	2.52	23.63		25,940	21,180	300	280	47,700	7,851

[a] Labor standards (cases): stamp case--700; form case, method A--260; form case, method B--315; form case, method C--440 (operate casing machine); fill case, method A--160; fill case, method B--185; set off, method A--195; set off, methods B and C--345 (units, cases per hour).

[b] See Appendix Table B for list of equipment replacement costs and annual fixed charges.

[c] Hourly wage, $1.64.

[d] Hourly wage, $1.80.

[e] Base wage plus 6 per cent to cover F.I.C.A., State Unemployment, and paid holidays.

[f] Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

[g] Includes labor, power, and variable repairs.

[h] Includes charges for skate conveyors at $4.20 per foot and steel roller conveyors at $6.75 per foot.

[i] Includes charges for case-stamping tables, stencil materials, case-forming tables, and case chutes where required.

[j] Calculated as percentage of replacement cost of equipment. Includes depreciation, 10 per cent; fixed repair, 1.5 per cent; taxes, 1 per cent; insurance, 1 per cent; and interest, 3 per cent (approximately 5.5 per cent on undepreciated balance). Total of 16.5 per cent.

[k] Job requires small amount of time and is performed by other workers.

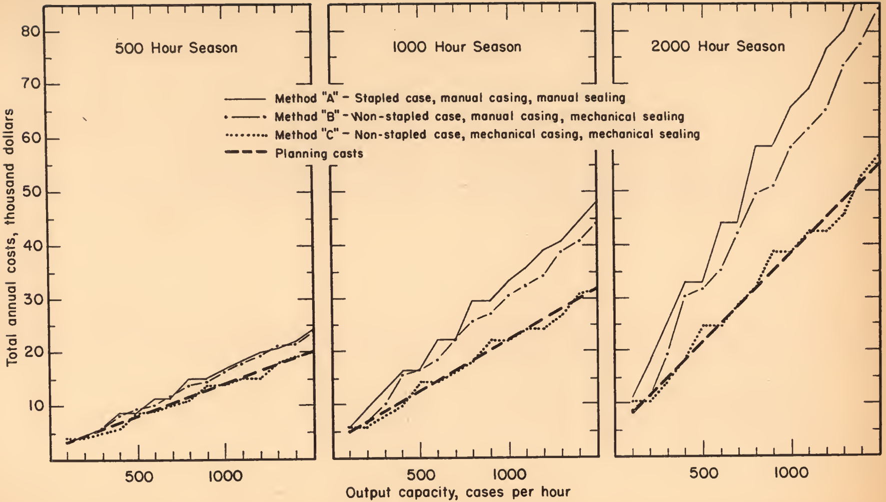

Figure 14. Total Annual Costs of Casing 10-Ounce Cartons, 24 Per Case, in Plants Processing Strawberries for Freezing in Relation to Method Used, Length of Operating Season, and Hourly Output Rate, California, 1958

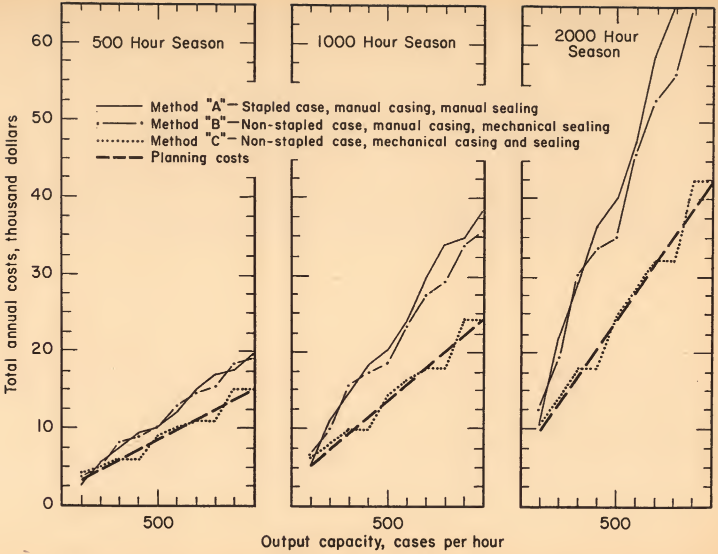

Figure 15. Total Annual Costs of Casing 16-Ounce Cartons, 24 Per Case, in Plants Processing Strawberries for Freezing in Relation to Method Used, Length of Operating Season, and Hourly Output Rate, California, 1958

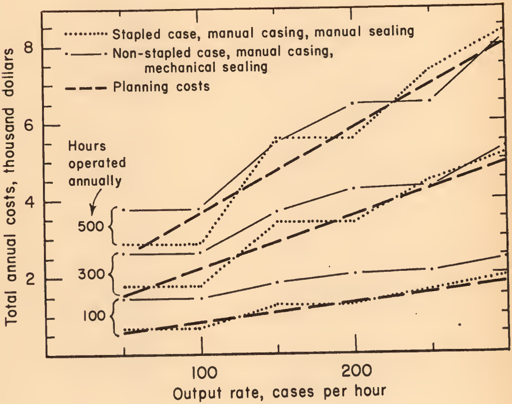

Figure 16. Total Annual Costs of Casing 6½-Pound Tins, 6 Per Case, in Plants Processing Strawberries for Freezing in Relation to Method Used, Length of Operating Season, and Hourly Output Rate California, 1958

superior to method A at higher rates of output and for longer seasons. Some savings in total seasonal cost through use of method C, where applicable, appear possible even in comparatively short seasons of 500 operating hours if output rate is high. This is due to the fact that the casing equipment used in method C has high fixed capacity and becomes most efficiently used at high rates of output. Since a very large portion of the costs of this method are fixed costs which do not increase with number of hours operated, the greatest advantage of method C appears when operating hours per season increase.

Planning costs for the casing stage, shown graphically by the heavy, dashed line of Figures 14 to 16, are given by the following equations:

10-ounce cartons, 24 per case

$$TSC = 475 + 232(h) + 343(P) + 94(h)(P)$$

where

TSC = Total season cost (in dollars) of casing 10-ounce cartons, 24 per case
h = Hundred hours per year of casing 10-ounce cartons, 24 per case
P = Thousand pounds per hour of 10-ounce cartons casing capacity.[1]

16-ounce cartons, 24 per case

$$TSC = 281 + 294(h) + 234(P) + 64(h)(P)$$

where

TSC = Total season cost (in dollars) of casing 16-ounce cartons, 24 per case
h = Hundred hours per year of casing 16-ounce cartons, 24 per case
P = Thousand pounds per hour of 16-ounce cartons casing capacity.[1]

6½-pound tins, 6 per case

$$TSC = 40 + 281(h) + 28(P) + 106.4(h)(P)$$

where

TSC = Total season cost (in dollars) of casing 6½-pound tins, 6 per case
h = Hundred hours per year of casing 6½-pound tins, 6 per case
P = Thousand pounds per hour of 6½-pound tins casing capacity.[1]

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[1] See footnote, page 26.

Receiving, Checkout, and In-Plant Transportation

The same equipment and crew can be used for receiving raw product and for moving materials and finished product within the plant. In all except the largest plants, this is the usual practice. These activities are, therefore, combined in this report to form one stage.

Strawberries are usually delivered to the processing plant on flat-bed trucks, the berries being in crates of approximately 14-pound capacity, stacked on pallets with an average of about 55 crates per pallet.

Processor responsibility begins with removal of pallets from the truck. In all plants observed, this is accomplished by fork-lift truck. The pallet is typically transferred from the truck to a dormant platform scale and then set aside to temporary storage to await processing. The receiving stage is considered to be completed when the pallet has been moved from temporary storage to the dump station.

The second use of fork-lift equipment is to move loaded pallets of packed product from the palletizing area to the checkout area where freezer personnel assume responsibility for the product. The fork-lift truck is also used for a variety of minor jobs such as handling packing materials.

Estimating Fork-Lift Truck Requirements

To enable estimation of the fork-lift truck time requirement in a given plant, measurements were taken of the time actually used for the various components of each of the jobs performed. It was found that per pallet time requirements averaged 3.391 minutes for receiving1/ and 2.050 minutes for checkout2/ activities.

Since the average weight of berries received per pallet is approximately 750 pounds, the receiving time per 1,000 pounds is 1.33 times the time requirement per pallet. The total receiving time per 1,000 pounds is thus 4.521 minutes.

1/ Includes removing the pallet of raw product from the truck, moving it to the scale, waiting for weighing, moving to temporary storage, removing from temporary storage and taking to dump station, placing empty crates on the truck, and moving the empty fork-lift truck to the grower truck and from the dump station.

2/ Includes pickup of the pallet, moving to the checkout area, recording the type and amount of product, time, etc., and returning with empty fork-lift truck to the palletizing area.

To enable estimation of fork-lift truck and driver time requirements based on plant-input capacity, estimates of checkout times are converted to a raw product basis. This requires specification of the amount of raw product removed before packaging, amount of sugar added, and weight of packaged product per pallet. These are estimated as follows for this analysis, based on typical values observed during this study: 5 per cent of the raw product is removed from the inspection belt as rots, the berry-sugar ratio is 4 to 1, and pallets are loaded with 90 cases of 10-ounce cartons--24 per case--or 1,350 pounds each. On this basis the time requirement for checkout activity is 1,803 minutes per 1,000 pounds of raw product input. If more berries are removed as rots, a smaller proportion of sugar is added to the berries, or more product is handled per pallet load, checkout time required per 1,000 pounds of raw product input will be reduced while the reverse of each of these conditions will increase the checkout time requirement.

In addition to the receiving and checkout operations described above, there are various miscellaneous operations performed by fork-lift trucks and operators. These consist primarily of handling packaging materials and are estimated to amount to 10 per cent of the total work time.

From the above results, total time requirements per 1,000 pounds of raw product are then found as follows:

Activity	Minutes required
Receiving	4.521
Checkout	1.803
Miscellaneous	.703
Unavoidable delay[1]	1.757
Total time requirement per 1,000 pounds of raw product	8.784

The total time requirement per 1,000 pounds of raw product given above can be applied to specified average receiving rates to estimate, as in other stages, the number of machines and workers required. This procedure ignores the fact, however, that a large part of the raw product is received before the processing operation begins and that much of the miscellaneous work can be performed while the plant is not operating. Therefore, we cannot necessarily say that a plant, which on the basis of its capacity output rate

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[1] Includes scheduled rest periods and nonproductive time due to uneven flow of product, personal time, etc. Various studies indicate that this varies in particular plants from 15 to 40 per cent of the total time input. Twenty per cent is used here as a practical minimum.

requires 60 minutes of fork-lift truck operation per hour of plant operation, must have just one fork-lift truck or that a plant of slightly higher output capacity requires two. However, on the basis of plant inventories and observations, this type of calculation appears to give a good indication of the number of fork-lift trucks required to fulfill requirements during peak load periods. The work performed before the day's processing operation begins is balanced by unavoidable periods of delay during the latter part of the processing period. On this basis one fork-lift truck will be required for every 6,800 pounds of plant-input capacity.

The hourly variable costs of operating a fork-lift truck consist of a charge of 29 cents[1] for variable repairs and maintenance, 21 cents for fuel and oil, and $2.30[2] for labor. The variable repairs and maintenance and the fuel and oil charges--a total of 50 cents per hour or 7 cents per 1,000 pounds--are made only for the hours of truck operation required to handle the plant capacity. The labor charge is based on the number of trucks required and the hours of plant operation.

Total annual costs of the receiving and in-plant transportation stage include, in addition to the costs of fork-lift truck operation, the costs of a receiving scale, berry crates, and pallets. Hourly variable and annual fixed charges for these items are given in Table 9. Total annual costs, based on this table, are shown in Figure 17.

Planning costs, given by the heavy, dashed line in Figure 17, are found from the following equation:

$$TSC = 664 + 122(H) + 237(P) + 44.9(H)(P)$$

where

TSC = Total season costs (in dollars) of the receiving, checkout, and in-plant transportation stage
H = Hundred hours plant is operated annually
P = Thousand pounds of strawberry input per hour.

Miscellaneous Equipment and Materials

Equipment costs have been included in the estimates of stage costs wherever the equipment is used exclusively in one stage. Many miscellaneous

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[1] Estimated on the basis of 0.5 per cent of the replacement cost of a fork-lift truck ($5,775) per 100 operating hours.

[2] Calculated on the basis of 1958 night wage rate of $2.17 plus 6 per cent to cover Social Security, State Unemployment Compensation, and paid holidays.

[illegible]

[illegible]

[illegible]

[illegible]

$$[illegible]$$

where

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 9

Equipment Replacement Costs, Annual Fixed Charges, and Hourly Variable Costs of Receiving, Checkout, and In-Plant Transportation with Respect to Plant-Input Capacity in Plants Processing Strawberries for Freezing, California, 1958

Input capacity (pounds per hour)	Variable costs per hour					Equipment replacement costs[a]			Annual fixed charges[a]			
	Fork-truck driver[b]	Fork truck[c]	Receiving scale[d]	Crates and pallets[e]	Total	Receiving scale	Crates and pallets	Fork truck	Crates and pallets	Receiving scale	Fork truck	Total
	dollars											
5,000	2.30	0.37	0.07	0.29	3.03	1,430	2,866	5,775	516	188	953	1,657
10,000	4.60	0.73	0.07	0.57	5.96	1,430	5,733	11,550	1,032	188	1,906	3,126
15,000	6.90	1.10	0.07	0.86	8.93	1,430	8,599	17,325	1,548	188	2,859	4,595
20,000	6.90	1.46	0.07	1.15	9.58	1,430	11,465	17,325	2,064	188	2,859	5,111
25,000	9.20	1.83	0.07	1.43	12.53	1,430	14,331	23,100	2,580	188	3,812	6,580

a/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

b/ Calculated on the basis of one driver per fork truck at $2.17 per hour plus 6 per cent to cover Social Security, State Unemployment, and paid holidays.

c/ Includes charges of $0.29 for variable repairs and maintenance and $0.21 for fuel and oil per hour of fork-lift truck operation.

d/ Estimated at 0.5 per cent of replacement cost per 100 hours of plant operation.

e/ Estimated at 1.0 per cent of replacement cost per 100 hours of plant operation.

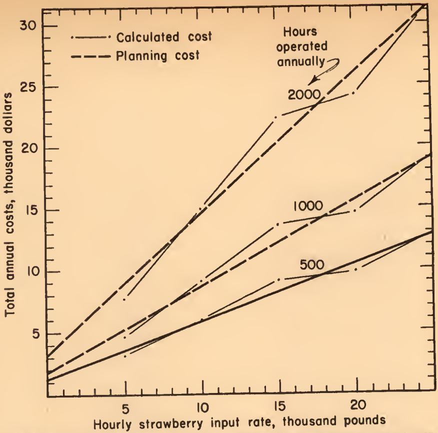

Figure 17. Total Annual Costs of Receiving, Checkout, and In-Plant Transportation in Plants Processing Strawberries for Freezing in Relation to Length of Operating Season and Hourly Strawberry-Input (Raw Product) Rate, California, 1958

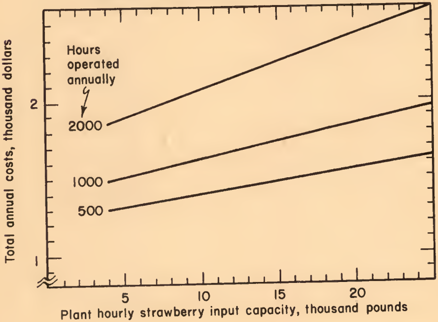

Figure 18. Total Annual Costs of Miscellaneous Equipment and Materials in Plants Processing Strawberries for Freezing with Respect to Length of Operating Season and Plant-Input (Raw Product) Capacity California, 1958

equipment items are not, however, assignable to particular stages but are part of the general plant equipment overhead. These are grouped together for inclusion in the following section on total plant costs. Individual equipment prices are given in Appendix Table C, and estimated total annual charges for these items are shown in Figure 18 and given by the equation below. Calculation of these costs include an annual fixed charge of 16.5 per cent of the equipment replacement cost to cover depreciation, repairs, insurance, taxes, and interest on investment and a variable charge per 100 operating hours of 0.5 per cent of the equipment replacement cost for repairs and maintenance plus an allowance for cleaning and housekeeping materials.

$$TSC = 1{,}072 + 32.5(H) + 9.2(P) + 1.3(H)(P)$$

where

TSC = Total season cost (in dollars) of miscellaneous equipment and materials
H = Hundred hours of plant operation per year
P = Thousand pounds of hourly plant capacity.

Superintendence and Miscellaneous Labor

There are several general labor and supervision categories in addition to those included in the above stage analyses. These include the plant superintendent, foremen, weighmaster, janitors, cleanup men, and utility men. In addition, each California strawberry processing plant is under continuous U. S. Department of Agriculture inspection which requires the presence of one inspector per plant.

The costs of U. S. Department of Agriculture inspection are paid for on a contractual basis. Requirements and costs of the other general categories vary among plants. These costs, based on observations of actual plant operations and studies of accounting records of labor utilization, are shown in Figure 19 and are given by the following equation:

$$TSC = 2{,}800 + 711(H) + 124(H)(P)$$

where

TSC = Total season cost (in dollars) of superintendence and miscellaneous labor
H = Hundred hours of plant operation per season
P = Thousand pounds of hourly plant capacity.

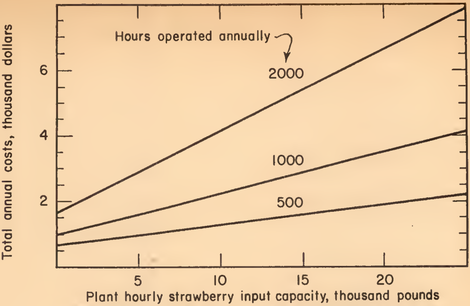

Figure 19. Total Annual Costs of Superintendence and Miscellaneous Labor in Plants Processing Strawberries for Freezing with Respect to Length of Operating Season and Plant-Input (Raw Product) Capacity California, 1958

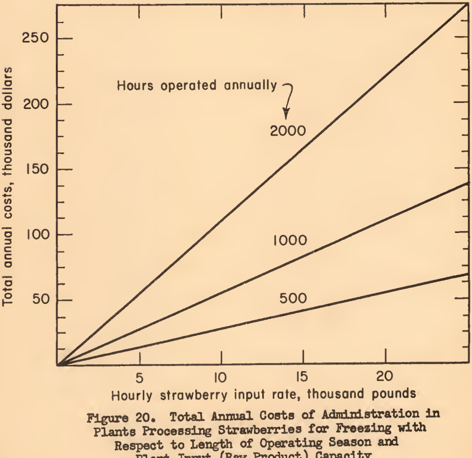

Figure 20. Total Annual Costs of Administration in Plants Processing Strawberries for Freezing with Respect to Length of Operating Season and Plant-Input (Raw Product) Capacity California, 1958

Administration and Office Costs

This cost component includes all those miscellaneous expenses associated with plant administration which cannot be directly assigned to a particular stage of the plant. It includes officer and office employee salaries, plant managers, fieldmen, office supplies, professional fees, and miscellaneous expenditures such as telephone, licenses, dues, subscriptions, donations, etc. It does not include sales expense. Several of the cost categories included are difficult to obtain individually from plant records or from actual observations due to the dual nature of the duties of many of the administrative personnel. In some plants the manager may perform bookkeeping or fieldman duties while bookkeepers or clerical workers often serve to some extent in an administrative capacity.

Costs of administration are related to both size of plant and length of processing season. While it seems logical that this cost would not increase proportionately with either of these variables due to fixed and partially fixed costs, the available data preclude a precise development of this relationship. Therefore, total administration costs are given on the basis of pounds of strawberries processed per year (pounds processed per hour times hours operated per year). This relationship is shown in Figure 20 and given by the equation below. Although this lacks the degree of precision desired, it is, nevertheless, felt to be a good approximation to costs of administration with respect to output in typical situations.

$$TSC = 551(H)(P)$$

where

TSC = Total season costs of administration and office operation
H = Hundred hours of plant operation per year
P = Thousand pounds per hour of plant capacity.

Building Costs

Floor space requirements for well-organized plants of various capacities, based on observations in the sample of plants included in this study, are given in Table 10. These total space requirements include space allowances for processing, temporary raw product storage, packing materials storage, tool room, rest rooms, and offices.[1] An exterior paved area is commonly provided

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[1] See Figure 2.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 10

Building Space Requirements, Replacement Costs, and Annual Fixed Charges with Respect to Plant-Input Capacity in Plants Processing Strawberries for Freezing, California, 1958

Plant strawberry input capacity	Enclosed building area requirement[a]	Building replacement cost[b]	Annual building charge[c]
pounds per hour	square feet	dollars	
5,000	5,983	29,312	2,609
10,000	11,546	46,595	4,147
15,000	17,109	63,880	5,685
20,000	22,672	81,164	7,224
25,000	28,235	98,448	8,762

[a] Estimated from the following equation: $A = 420 + 1112.6X$ where A is the enclosed area in square feet and X is the plant strawberry input capacity in thousand pounds per hour.

[b] Estimated from the following equation which is based on 1957 wage rates for construction labor and prices for building materials: $C = 10,722 + 3.107X$ where C is the building cost and X is the plant enclosed area in square feet. This includes the cost of building with concrete side wall and floor and asphalt roof, mezzanine, sanitary plumbing and primary water lines (but excluding plumbing costs assignable to specific equipment items), and all electrical wiring and lighting (except that which is assignable to specific equipment items).

The basic building replacement cost information was obtained from Sammet, L. L., Economic and Engineering Factors in Agricultural Processing Plant Design (unpublished Ph.D. thesis, University of California, Berkeley, 1958), p. 434.

[c] This is based on the building replacement cost and includes depreciation, 2.5 per cent; repairs, 1.8 per cent; insurance, 0.6 per cent; taxes, 1.0 per cent; and interest, 3.0 per cent (approximately 5.5 per cent on undepreciated balance) for a total of 8.9 per cent. This charge is the planning cost for buildings and is represented by the following equation: $C = 1,070 + 307.7X$ where C is the annual building charge and X is the plant strawberry input capacity in thousand pounds per hour.

The use life and annual charge percentage of replacement cost of buildings was derived from information contained in Sammet, L. L., and I. F. Davis, Building and Equipment Costs, Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, December, 1952), p. 21. (Giannini Foundation Mimeographed Report No. 141.) Processed.

to serve as a receiving area and occasional storage area for packing materials, empty berry crates, pallets, or raw product awaiting processing.

Two types of construction are common in California strawberry processing plants. In general, the smaller and older plants are of frame construction with corrugated, galvanized iron sheets on roof and sides. The newer plants tend to have concrete sidewalls and asphalt roofing. All plants have concrete floors at ground level. Clear height from the floor to the roof trusses varies from 15 to 25 feet.

Annual building costs are approximately equal for these two types of construction when length of building life, upkeep, and differences in insurance rates are considered. Costs shown here are for concrete sidewalls and asphalt roof since the trend is to that type of construction.

Replacement costs--based on engineering estimates using 1957 wages and prices of materials--and annual fixed charges for these plants including the building, plumbing, wiring, and exterior paving are given in Table 10. The wiring charge includes the main panel, general lighting, and all overhead wiring. Plumbing is provided only for the rest rooms and primary water lines. Electrical drops and switches and plumbing connections to specific items of equipment are included in the installation cost for that equipment.

PLANT COSTS

The preceding section has dealt with a description of the various cost components, alternative techniques used within stages, and a synthesis of costs by cost component. This section uses the cost relationships developed for individual components to indicate the total cost of processing in relation to rate of plant output per hour and hours operated per season.

Simplifications

There are many factors affecting the costs of processing strawberries for freezing. Several of these, however, are so nearly constant per unit of output, regardless of plant size or hours of operation, that they add a constant amount to average costs. These have been omitted from the analysis to avoid the introduction of unnecessary complications. Limits have been imposed on certain other variables to keep the analysis within workable limits.

These limitations, however, do not result in unrealistic conditions of operation. These specifications, several of which have been referred to previously, are:

1. Plant size is defined in terms of the number of quality inspection belts used. The capacity per belt is 5,000 pounds of raw product per hour.
2. A capacity rate equal to or exceeding that of the inspection belts is provided at all other plant stages.
3. Packed product is limited to Grade A sliced and Grade B whole strawberries.[1/]
4. California processing plants normally operate at night to minimize the delay between picking and processing. Therefore, the 1958 union wage scale for night shift work is used. It is assumed that no work is required that involves premium overtime wage rates.
5. With uniform operation with respect to output rate in any given plant, variation in daily volume is attained by changes in hours worked per day. Since the union contract agreement requires payment for a minimum of four hours on any day worked, it is assumed that sufficient raw product is received to require at least four hours of capacity operation.
6. Freezing and selling costs were not considered in the analysis and so are omitted from the cost relationships given.
7. The cost of sugar per pound of processed berries in any given plant is a constant, dependent upon the berry-sugar ratio and whether the sugar is purchased in bags or in bulk. This cost is not included but can be easily computed from the current price. Bulk purchase of sugar is assumed.
8. Packing materials cost is governed by the type of product. This cost is not included but would add a constant amount per pound depending upon the container used.
9. The cost of land suitable for processing facilities varies widely and is, furthermore, difficult to determine. To avoid the use of land prices which apply to a specific area and an unnecessary limitation of the area of applicability of this study, this cost is also omitted.

[1/] The effect of this limitation is confined largely to the sorting labor requirement and costs. Guides for adjusting the values given to requirements for Grade A whole and Grade B sliced are given on pages 15 and 16.

Plant Cost Calculations

Total plant cost for any given plant and volume of output is the sum of the costs incurred by the individual cost components. Total plant cost in an efficient plant is then the sum of the costs of least-cost methods within each cost component.[1] Equations which describe the costs of least-cost techniques of each component have been developed in conjunction with the stage-cost syntheses in the preceding section of this report. These equations can now be combined to give total plant cost.

The coefficients (multipliers) of the cost equations developed for each plant stage and cost component are summarized in Table 11. The cost components are segregated according to the volume category--that is, whether raw product or packed--on which they are based. Those components which do not vary with the form of the final product are based on the quantity of raw product processed (quantity dumped) and are grouped in the table as "common costs." The "slicing and sugar mixing" stage is also on a raw product basis but applies only to sliced berries. The second section of this table contains those cost components which are based on quantity of output (pounds packed) of each of the products considered in this report.

An individual equation is read from this table by applying the multipliers in the table to the variables in the subheading. For instance, the cost equation for the dumping stage is:

$$TSC = 111 + 108.8(I) + 197.2(H) + 38.9(I)(H)$$

in which TSC is the total season cost in dollars, (I) is the thousands of pounds of plant hourly raw product capacity, and (H) is the hundreds of hours of annual plant operation. The multipliers of this equation appear in the first line of Table 11.

Likewise, the equation giving the costs applying to all products (total common costs) is:

$$TSC = 6{,}844 + 863.3(I) + 1{,}278.7(H) + 950.5(I)(H) + 10.43(I)(H)(Q)$$

The equation giving the additional costs which apply <u>only</u> to 10-ounce cartons, packed 24 per case, is:

$$TSC = 963 + 930(P) + 587(h) + 177.3(P)(h)$$

---

[1] For this to hold true, it is necessary that the least-cost technique in each stage not hinder the use of the least-cost technique of any other stage.

TABLE 11

Summary of Planning Cost Equations for Cost Components and Stages in Plants Processing Strawberries for Freezing California, 1958

a. Cost Categories Based on Input (Raw Product) Capacity

	Variables a/				
Cost category	(C)	(I)	(H)	(I)(H)	(I)(H)(Q)
	cost multipliers				
Common costs					
Dumping	111	108.8	197.2	38.9	
Quality sort and size grade	343	85.6	190.0	186.8	10.43
Sugar supply	784	115.0	26.0	3.6	
Receiving, checkout, etc.	664	237.0	122.0	44.9	
Miscellaneous equipment	1,072	9.2	32.5	1.3	
Miscellaneous labor	2,800		711.0	124.0	
Administration				551.0	
Building	1,070	307.7			
Total	6,844	863.3	1,278.7	950.5	10.43
Slicing and sugar mixing	335	44.0	14.0	1.6	

b. Cost Categories Based on Output (Packout) Capacity

	Variables a/			
Cost category	(C)	(P)	(h)	(P)(h)
	cost multipliers			
10-ounce cartons, 24 per case				
Filling	488	587	355	83.3
Casing	475	343	232	94.0
Total	963	930	587	177.3
16-ounce cartons, 24 per case				
Filling	488	367	332	55.7
Casing	281	234	294	64.0
Total	769	601	626	119.7
$6\frac{1}{2}$-pound tins, 6 per case				
Filling	1,133	291	221	56.4
Casing	40	28	281	106.4
Total	1,173	319	502	162.8
30-pound tins, sliced berry				
Filling	169		179	114.0
30-pound tins, whole berry				
Filling	204	22	205	123.1

a/ The cost equation variables are as follows:
C = A constant cost which is incurred regardless of length of season or size of plant.
I = Plant-input capacity in thousand pounds per hour (thousand pounds dumped).
H = Hundred hours of plant operation.
Q = Per cent of berry input that must be removed by quality sort labor. It includes sortouts and rots.
P = Packout capacity of the particular cost category in thousand pounds per hour.
h = Hundred hours of operation of the particular cost category.

where TSC is the total season cost in dollars, (P) is the hourly output capacity in thousands of pounds per hour of 10-ounce cartons, packed 24 per case, and (h) is the hundreds of hours of annual operation of this product.

Total plant cost is found by taking the sum of the costs of the applicable cost categories. Separate cost calculations are made with respect to each volume category, and the results are summed to obtain total plant cost. For instance, to obtain the total cost of packing sliced strawberries in 10-ounce cartons (24 per case), the common costs, slicing and sugar mixing costs, and 10-ounce carton costs must be found.

Consider, for example, a plant which has a raw product input capacity of 15,000 pounds per hour, operates 1,000 hours per year, processes berries of such quality that 5 per cent of the berries must be removed as sortouts and 5 per cent as rots (a total of 10 per cent removed from the inspection belt), uses a berry-sugar ratio of 4 to 1, and packs 10-ounce cartons of sliced strawberries. The cost components for this plant based on raw product input are the combination of the "common costs" and "slicing and sugar mixing." These costs are:

Common costs

$$\begin{aligned} TSC &= 6{,}844 + 863.3(I) + 1{,}287.7(H) + 950.5(I)(H) + 10.43(I)(H)(Q) \\ &= 6{,}844 + 863.3(15) + 1{,}287.7(10) + 950.5(15)(10) + 10.43(15)(10)(10) \\ &= \$190{,}891 \end{aligned}$$

Slicing and sugar mixing

$$\begin{aligned} TSC &= 335 + 44(I) + 14(H) + 1.6(I)(H) \\ &= 335 + 44(15) + 14(10) + 1.6(15)(10) \\ &= \$1{,}375. \end{aligned}$$

If, as in this example, 10 per cent of the berries are removed from the inspection belt and the berry-sugar ratio is 4 to 1, the 15,000 pounds per hour of raw product input is reduced to 13,500 pounds of berries, while 3,375 pounds of sugar are added, making a total output of 16,875 pounds per hour. Using this figure as output pounds, the cost calculation for 10-ounce cartons is as follows:

$$\begin{aligned} TSC &= 963 + 930(P) + 587(h) + 177.3(P)(h) \\ &= 963 + 930(16.875) + 587(10) + 177.3(16.875)(10) \\ &= \$52{,}446. \end{aligned}$$

The cost of packing the sortouts can be found from the 30-pound tin, whole berry equation. Five per cent of the raw product input is removed from

the inspection belt as sortouts and the berry-sugar ratio is 4 to 1; thus, 750 pounds of berries plus 188 pounds of sugar (a total of 938 pounds) are packed per hour and this cost is:

$$\begin{aligned}\text{TSC} &= 204 + 22(P) + 205(H) + 123.1(P)(h)\\ &= 204 + 22(0.938) + 205(10) + 123.1(0.938)(10)\\ &= \$3,430\end{aligned}$$

The total plant cost is now the total of all of these costs.

Common costs	$190,891
Slicing and sugar mixing	1,375
10-ounce cartons, 24 per case	52,446
Sortouts	3,430
Total	$248,142

Average cost is found by dividing total annual cost by the number of pounds processed. This can be done on the basis of pounds of raw product input or packed product output. With input rate given, packout rate is determined by berry quality and the amount of sugar added to the berries. This has been demonstrated in the above example where 15,000 pounds of hourly berry input became 16,875 pounds of hourly packout. Average cost per 1,000 pounds on an input basis, in this case, is $16.54 ($248,142 divided by 15,000,000 pounds) and on a packout basis is $14.70 ($248,142 divided by 16,875,000 pounds).

Using the cost equations as described above, the total season cost can be estimated for any specified situation--plant size, length of operating season, berry quality, berry-sugar ratio, and product (or products). However, each of these cost determinants must be specified in advance to allow this cost calculation. The effect each of them has on total and average costs will be illustrated using the estimating procedure given above.

In any given plant, capacity input rate is determined by the number of quality-inspection belts. Therefore, in a plant operating at capacity, quantity is specified in terms of input in calculation of total annual and average unit costs. However, these costs are of more interest and value on a product packout basis; so in the following demonstrations of the effect of the various determinants on costs, they are given in these terms.

Total Plant Costs and Effect of Cost-Determinant Variation

Products Packed and Plant Size

Total season costs for the five different forms of packed berries considered in this report are shown for a 1,000-hour season and in relation to packed output rate in Figure 21A. Panel B of Figure 21 expresses these total costs in terms of average costs per 1,000 pounds of product packed. These curves are the long-run planning curves--total and average--for plants packing any one of the products shown under the conditions specified. This figure shows that packing in larger containers tends to result in a lower processing cost per pound. The figure also illustrates the effect of plant size on these costs. Average costs decrease very rapidly with increased plant size in the lower ranges of plant size but less rapidly as plant size becomes greater. This decrease of average cost as plant size increases is due to a combination of the spreading of certain fixed costs--such as buildings, equipment, and supervision--over a greater poundage and the substitution of various cost-reducing techniques in the larger plants.

Length of Operating Season

There are many fixed and partially fixed elements of cost which either do not vary or do not vary proportionately with the number of hours operated. A longer processing season spreads these costs over a greater output with a resulting decrease in unit costs. Figure 22 demonstrates the effect of the number of hours operated annually on total season and average unit costs using 10-ounce cartons as the example. This figure shows that, while there is an appreciable decrease in the cost per pound as length of season increases, the majority of this decrease comes in the shorter seasons. The decrease in average cost with each additional 100 hours of annual operation becomes less as season length increases.

Strawberry Quality

Berry quality, as measured by the quantity of berries that must be removed from the inspection belt by quality-sort labor, affects total and unit processing costs in two ways. Poor berry quality, for example, increases the costs of sorting a given quantity of raw product; but with a reduced packed

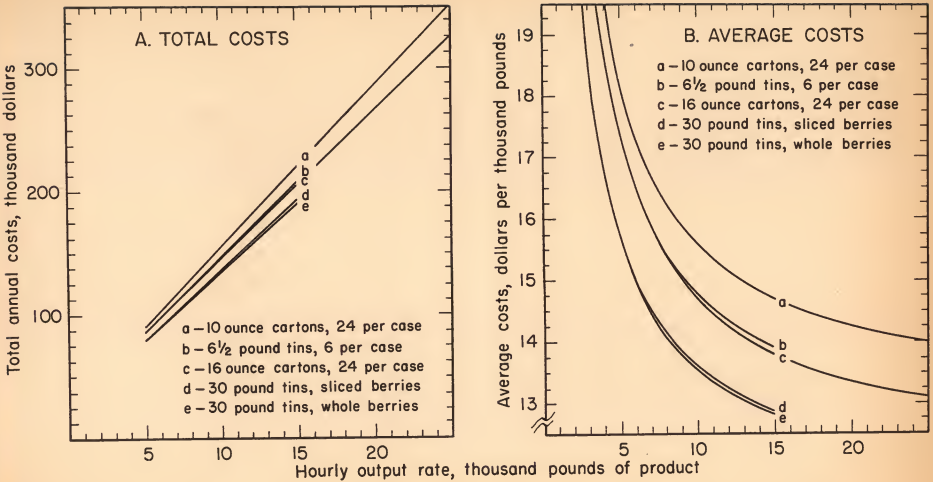

Figure 21. Total and Average Planning Costs of Packing Various Products in Single-Product Plants Processing Strawberries for Freezing—Costs Based on Output Poundage, a 1,000-Hour Operating Season, 10 Per Cent of the Berry Input Removed from the Inspection Belt, and a 4 to 1 Berry-Sugar Ratio, California, 1958

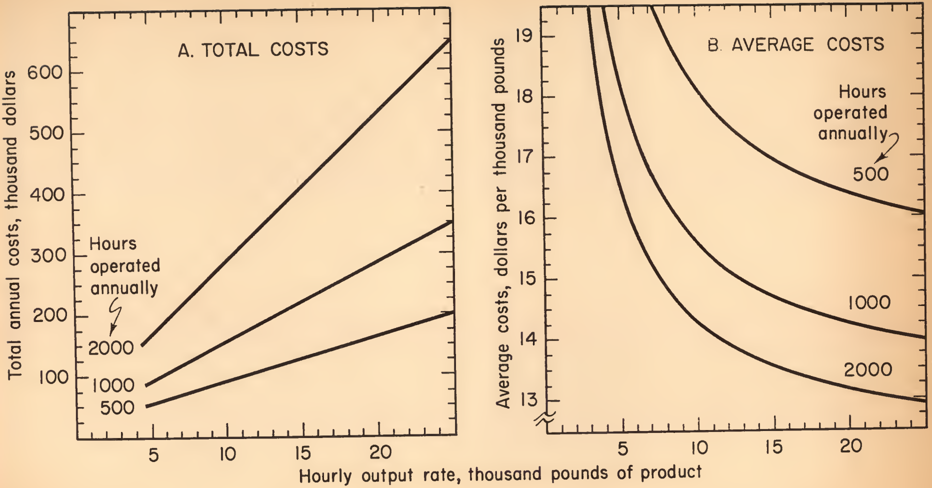

Figure 22. The Effect of Length of Season on Total and Average Planning Costs in Plants Processing Strawberries for Freezing in 10-Ounce Cartons, 24 Per Case--Costs Based on Hourly Output Poundage, a 1,000-Hour Operating Season, 10 Per Cent of the Berry Input Removed from the Inspection Belt, and a 4 to 1 Berry-Sugar Ratio California, 1958

volume, the total costs of filling and casing are reduced. Costs per 1,000 pounds processed increase, of course, as the proportion of sortouts increases. This effect is especially noticeable if unit costs are based on packed output rate since, to obtain a given rate of packed output, increasing quantities of raw product must be run as the proportion of rots and sortouts increases. These effects are illustrated in Figure 23 which gives average unit costs in relation to both input rate and output rate.

Underutilization of Plant Capacity

The cost relationships which have been developed are based upon plant operation at its planned capacity. These relationships do not apply to plants operating at other than their capacity rates. In specific plants in which the equipment and physical layout are established, much of the labor and other variable inputs are capable of adjustment to less than capacity rates, but certain costs--such as equipment and building--are fixed. These comparatively high fixed costs continue to be incurred when the plant operates at less than capacity. Since they must be absorbed by a decreased quantity of product, unit costs increase. This is illustrated in Figure 24. The dashed lines in these charts are the planning cost curves for 10-ounce cartons shown in Figure 21. They represent total (or average) cost in plants of different size, assuming the plant operates at capacity. The solid lines of Figure 24 show the effect on costs when plants with capacity rates of 5,000, 15,000, and 25,000 pounds per hour are operated at rates of less than capacity. As the rate of operation increases in these particular plants, total costs increase uniformly until plant capacity is reached. Average costs, however, decline as output rate increases until plant capacity is reached. In each plant both total and average costs at undercapacity rates of output are above those shown by the planning curve. As the plant operating rate moves toward its capacity, its costs move toward the planning costs until the two become equal where plant capacity is reached.

Production in Multiproduct Plants

The analysis up to this point has been of plants packing only one product--one container size and either sliced or whole berries. The usual practice, however, is for a given plant to produce two or more forms of packed output.

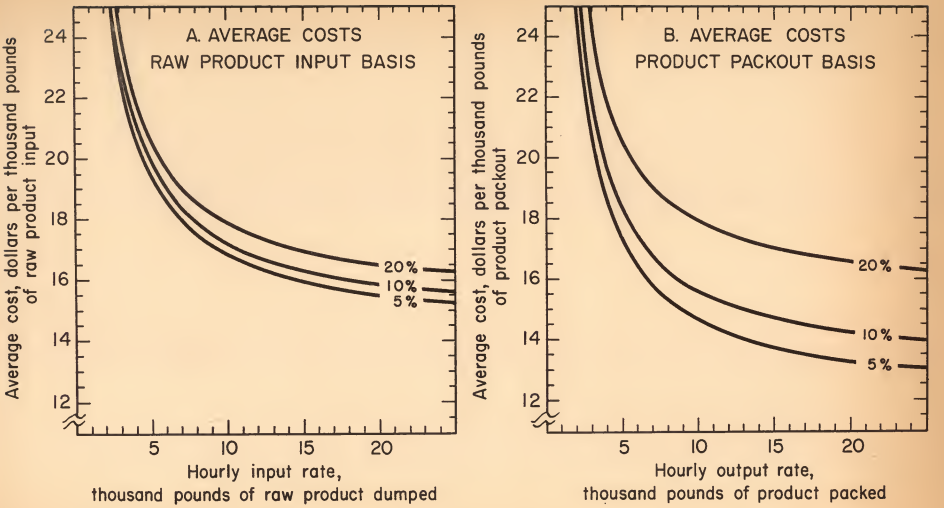

Figure 23. The Effect of Raw Product Berry Quality, as Indicated by Per Cent of Berries Removed from the Inspection Belt by Quality-Sort Labor, on Average Planning Costs in Plants Packing Strawberries for Freezing in 10-Ounce Cartons, 24 Per Case--Costs Based on a 1,000-Hour Operating Season, a 4 to 1 Berry-Sugar Ratio, Equal Quantities of Rots and Sortouts, and Either (A) Input Poundage (Raw Product Dumped) or (B) Output Poundage (Product Packout), California, 1958

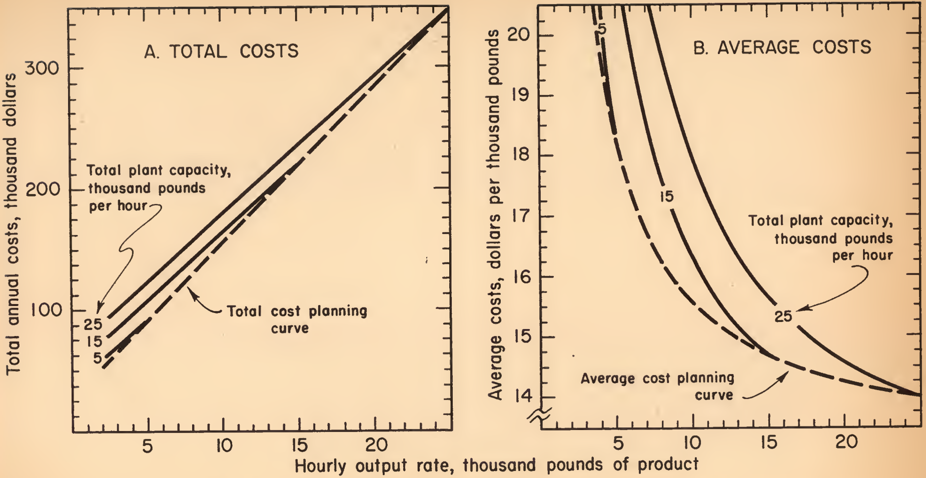

Figure 24. The Relationship Between Costs when Operating at Capacity and Costs when Operating at Less than Capacity in Plants Processing Strawberries for Freezing in 10-Ounce Cartons, 24 Per Case--Costs Based on Hourly Output Poundage, a 1,000-Hour Operating Season, 10 Per Cent of the Berry Input Removed from the Inspection Belt, and a 4 to 1 Berry-Sugar Ratio, California, 1958

This study has endeavored to establish costs separately for each product, wherever those costs differ by product, and to group those costs which are the same regardless of product. The berries are handled in the same manner from receipt at the plant through the sorting and grading stage making these costs the same, on a poundage basis, regardless of final product. In addition, various other cost components such as administration, miscellaneous equipment and labor, supervision, and building are considered to be independent of product being packed. These are the "common costs" of this analysis. Berries may move from the "common" stages to any one or all of the product-filling and casing stages at any given time. Because of this joint use of the "common" stages by all of the products packed in a plant, the costs of these stages must be allocated to the various products.

The costs of packing one product in a multiproduct plant consist of the costs peculiar to that product plus an assigned share of the "common costs." There are many ways in which these costs could be divided among products depending upon the particular plant situation. They can, for instance, be allocated according to total value of packed output, to hours of direct labor expended on each product, or in a fixed proportion according to what each product seems able to support or the importance placed upon each product by the plant management. In this study they are divided according to the pounds of each product packed based on the observation that the particular product involved has no effect on these cost components. Slicing and sugar mixing costs are divided among only the sliced products.

Because of differing techniques used in efficient plants of different sizes and because of fixed costs which may be spread over a greater quantity of berries in a large than in a small plant, the costs of processing a given quantity of berries through the "common" stages of a large plant operating at its capacity are less than those which would result in a small plant. Therefore, the total processing cost of the given quantity of berries in a large plant will be less than the cost of processing that same quantity of berries in a small plant.

For example, if a single-product plant of 5,000-pound-per-hour raw product input capacity operates 800 hours per year and the berries are of such quality that 10 per cent must be removed by quality-sort labor, total costs, less the sortout filling cost, can be found by using the equations of Table 11. They are:

Common costs

$$\begin{aligned} TSC &= 6{,}844 + 863.3(5) + 1{,}278(8) + 950.5(5)(8) + 10.43(5)(8)(10) \\ &= \$63{,}582 \end{aligned}$$

Slicing and sugar mixing

$$\begin{aligned} TSC &= 335 + 44(5) + 14(8) + 1.6(5)(8) \\ &= \$731 \end{aligned}$$

10-ounce cartons, 24 per case.

If 10 per cent of the raw product is removed as sortouts and rots and the berry-sugar ratio is 4 to 1, every pound of raw product input becomes 1.125 pounds of packout. Therefore, the 5,000 pounds of input becomes 5,625 pounds of output, and this cost equation is:

$$\begin{aligned} TSC &= 963 + 930(5.625) + 587(8) + 177.3(5.625)(8) \\ &= \$18{,}869 \end{aligned}$$

The total annual cost of processing 10-ounce cartons in this plant is the sum of these costs or $83,182.

If the same quantity of 10-ounce cartons is packed in a plant of total capacity of 10,000 pounds per hour, assuming all products are sliced, the costs of packing the 10-ounce cartons are composed of one half of the common and slicing and sugar mixing cost for 10,000 pounds plus the costs of filling and casing 5,000 pounds of 10-ounce cartons. The cost equations are solved as follows:

Common costs

$$\begin{aligned} TSC &= \tfrac{1}{2}(6{,}844 + 863.3(10) + 1{,}278.7(8) + 950.5(10)(8) + 10.43(10)(8)(10)) \\ &= \tfrac{1}{2}\,(\$110{,}091) \\ &= \$55{,}046 \end{aligned}$$

Slicing and sugar mixing

$$\begin{aligned} TSC &= \tfrac{1}{2}(335 + 44(10) + 14(8) + 1.6(10)(8)) \\ &= \tfrac{1}{2}(\$1{,}015) \\ &= \$508 \end{aligned}$$

10-ounce cartons, 24 per case

$$\begin{aligned} TSC &= 963 + 930(5.625) + 587(8) + 177.3(5.625)(8) \\ &= \$18{,}869, \end{aligned}$$

and the total annual cost of processing 10-ounce cartons in this plant is $55,048 plus $508 plus $18,869, a total of $74,423. The larger plant thus packs the same quantity of berries in 10-ounce cartons for a total cost of $8,759 less than the smaller plant ($83,182 minus $74,423).

The relationship between planning costs in a single-product plant and planning costs of a specific product which represents only a portion of total output of a multiproduct plant is shown in Figure 25. The dashed lines of

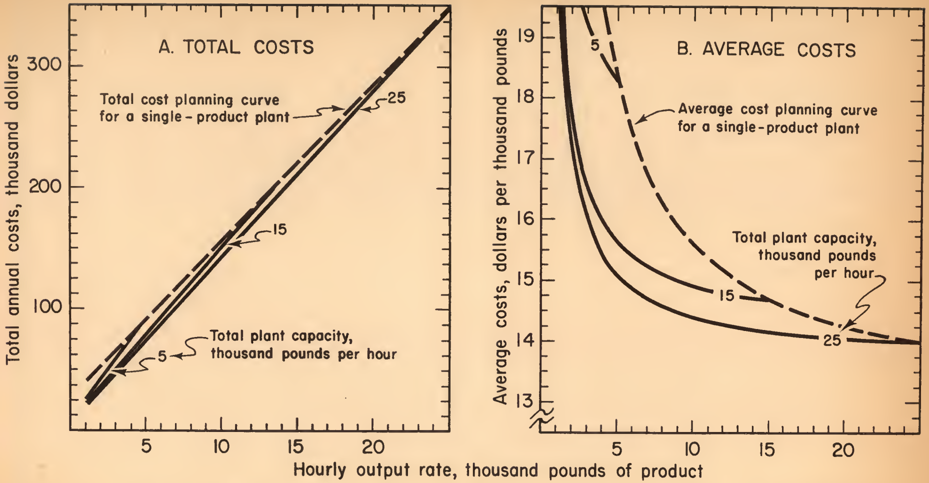

Figure 25. The Relationship Between Planning Costs in Single-Product Plants Processing Strawberries for Freezing and Planning Costs of a Specific Product which Represents a Portion of Total Output of a Multiproduct Plant Using 10-Ounce Cartons, 24 Per Case, as an Example—Costs Based on Hourly Output Poundage, a 1,000-Hour Operating Season, 10 Per Cent of the Berry Input Removed from the Inspection Belt, and a 4 to 1 Berry-Sugar Ratio, California, 1958

this figure are the planning costs for a single-product plant shown in Figure 21 for 10-ounce cartons. The solid lines are the costs which would apply to a particular product--in this example, 10-ounce cartons--if the product were packed in a larger plant packing other strawberry products. The vertical distance between the dashed line and a solid line is the difference in cost of packing in single-product or multiproduct plants.[1/] For instance, if a plant of 5,000-pound input capacity operates under the conditions given in the caption and packs only 10-ounce cartons, the total season cost is $99,500; and if this same quantity is packed in a plant of 25,000-pound total capacity, the total season cost of the 10-ounce cartons is $83,500--a difference of $16,000.

Just as in the demonstration of the higher costs incurred in plants working at less than capacity, these curves gradually move together until they merge at the point where the product involved uses the entire plant capacity. However, in this case the single-product planning curve (broken line) is above (of higher cost) the planning curves which apply to given products within multiproduct plants.

[1/] This difference is not due, per se, to the fact that a product is packed in a multiproduct plant but to the larger total plant capacity--due to multiproduct operation--and the resultant economies of scale which become available to certain parts of the process for each specific product.

[illegible]

[illegible]

[illegible]

SUMMARY

There has been a rapid expansion in frozen strawberry production in the western states in recent years requiring a corresponding expansion in processing facilities. The purposes of this report are to present information concerning relative costs of different methods or techniques used in preparing strawberries for freezing as an aid to plant operators when planning new facilities or alterations to present facilities and to develop estimates of total costs of processing strawberries under California conditions.

For convenience of analysis, crew and equipment requirements are given for each of several plant stages for various rates of operation for each of the methods commonly used. Most economical methods with respect to annual operating hours and hourly rates of operation are determined. High labor-consuming methods frequently are shown to be most efficient at low output rates and for short seasons with mechanization becoming more advantageous as output rate and season length increase. Planning curves and planning equations, which indicate costs in relation to output rate when least-cost techniques are used, are developed for each plant cost component.

The cost components considered in this study are: (1) dumping, (2) quality sorting and size grading, (3) slicing and the sugar system, (4) container filling, (5) casing, (6) receiving, checkout, and in-plant transportation of products and materials, (7) miscellaneous equipment and materials, (8) supervisory and miscellaneous labor, (9) office and administrative expense, and (10) building costs.

In the dumping stage the costs of two methods, called "manual" and "mechanical," are given. The manual method, although used in the majority of California plants at present, is shown to be the most efficient in only the small plants operating comparatively short seasons.

While quality sorting and size grading is one of the high cost stages, this operation is highly standardized among the plants studied and costs of only one method are presented. There are two methods--manual and mechanical--of supplying sugar to the metering and mixing equipment of the slicing and sugar system stage. In the manual method sugar is manually dumped from 100-pound bags to a hopper over the metering device, while in the mechanical method, bulk sugar is delivered to the plant by tank truck, placed in a silo or storage bin, and then moved by gravity and/or power conveyor as needed to point of use. The sugar supply costs are lowest for the manual method only in small plants operating short seasons. A sugar price differential eliminates even this area of advantage for plants operating under California conditions.

SUMMARY

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The methods used in the container-filling stage vary from a highly mechanized operation with 10- and 16-ounce cartons to little mechanization in filling 30-pound tins. While the filling methods are dissimilar for different containers, for particular containers they are very similar among different plants. In large plants with long-season operation, costs of filling 10- and 16-ounce cartons are substantially less with the use of a mechanical aid in feeding cartons to the filler than with manual methods. There is little difference in costs with these methods with short-season operation in small plants.

Manual placement of sugar in 30-pound tins as the tin is filled with strawberries was estimated to result in higher cost than mechanical metering and mixing for all except very short seasons and low-output rates.

There are three methods employed for casing consumer-size cartons. Method A uses a stapled case, manually places the cartons into the case, and manually seals the case. Method B uses a top- and bottom-glued case, manually places the cartons into the case, and mechanically seals the case. Method C uses a top- and bottom-glued case, mechanically places the cartons into the case, and mechanically seals the case. Methods A and B are nearly equal in cost for plants of all sizes for a 500-hour season. For longer seasons, method B has a cost advantage. The total seasonal costs of method C, however, are lower than for either methods A or B for all except very small plants operating short seasons.

Cost estimates developed for plant cost components are brought together to estimate total plant costs. Based on the planning equations developed in this study, average processing costs are shown to decline as length of season is increased. The majority of this decline comes in the shorter seasons with the decrease in average cost being less for each additional 100 hours of annual operation as season length increases.

The effect of berry quality on processing cost is especially noticeable when costs are based on packed output. Poor berry quality increases the cost of sorting a given quantity of raw product and, to obtain a given quantity of packed output, greater quantities of raw product must be run.

A combination of the ability of a large plant to make more efficient use of its building, equipment, supervisory personnel, etc., and the use of various cost-reducing techniques which are economical only in large plants results in decreasing average processing cost as plant size increases. Most of the economies of scale are realized by plants of 10,000-pound-per-hour capacity and very little additional decrease in average processing cost is obtained by plants of over 15,000-pound-per-hour capacity.

APPENDIX TABLE A

Summary of Labor Production Standards for Jobs Performed in Plants Processing Strawberries for Freezing, California, 1958

Job classification and description	Production standard units per hour
Dump crate, manual Get full crate from pallet, dump, place crate on conveyor to crate washer.	350 crates
Dump crate, mechanical Get full crate from pallet and set on conveyor to dumper. Alternate with worker on less strenuous job.	1,200 crates
Empty crate, set off Get empty crate from conveyor and stack on pallet.	525 crates
Feed 10-ounce cartons, without mechanical aids Get empty cartons from paper bag and place on conveyor to filler.	185 cases (24 cartons per case)
Feed 10-ounce cartons, with mechanical aids Get empty cartons and place on bag unloader.	280 cases (24 cartons per case)
Feed tins, 6½ pound Transfer round tins 2 to 4 at a time from paper bag to filler.	200 cases (6 tins per case)
Fill case	
Method A--Get case from case chute, fill, push case aside.	
10-ounce cartons, 24 per case	160 cases
16-ounce cartons, 24 per case	120 cases
6½-pound tins, 6 per case	120 cases
Method B--Get case from conveyor on which case is filled, fill, push aside.	
10-ounce cartons, 24 per case	185 cases
16-ounce cartons, 24 per case	130 cases
6½-pound tins, 6 per case	130 cases
Fill 30-pound tin, whole berries Get tin from can race or stack, place under spout, open spout and fill tin to proper weight, push aside	140 tins

(Continued on next page.)

Job classification and description	Production standard units per hour
Fill 30-pound tin, sliced berries Get tin from can race or stack, place under spout, open spout and fill tin to proper weight, push aside.	155 tins
Form case	
Method A--Get flat case from table and form, stitch case bottom, set aside to case chute.	
10-ounce cartons, 24 per case	260 cases
16-ounce cartons, 24 per case	235 cases
6½-pound tins, 6 per case	235 cases
Method B--Get flat case from table and form, invert case and push bottom flaps down, set aside to conveyor or stack.	
10-ounce cartons, 24 per case	315 cases
16-ounce cartons, 24 per case	280 cases
6½-pound tins, 6 per case	280 cases
Method C--Get flat case from table, form, and place on casing machine.	
10-ounce cartons, 24 per case	440 cases
16-ounce cartons, 24 per case	440 cases
Palletize cases	
Method A--Apply glue to case top flaps, close flaps, and set case aside to pallet. Includes time allowance for obtaining pallets from temporary storage and for placing layer dividers between every second layer.	
10-ounce cartons, 24 per case	195 cases
16-ounce cartons, 24 per case	175 cases
6½-pound tins, 6 per case	130 cases
Methods B and C--Obtain sealed case from conveyor, set aside to pallet. Includes time allowance for obtaining pallets from temporary storage and for placing layer dividers between every second layer.	
10-ounce cartons, 24 per case	345 cases
16-ounce cartons, 24 per case	270 cases
6½-pound tins, 6 per case	130 cases
Palletize 30-pound tins Place lid on tin, move tin from conveyor to pallet, place slats between layers of tins.	165 tins
Stamp case Obtain bundles of flat cases from temporary storage, remove twine binding, apply one stamp per case, and transfer to case-form table	

(Continued on next page.)

Appendix Table A continued.

Job classification and description	Production standard units per hour
10-ounce cartons, 24 per case	700 cases
16-ounce cartons, 24 per case	640 cases
6½-pound tins, 6 per case	640 cases
Stamp 30-pound tin Get tin from paper bag, place one stamp on tin and stack tin beside fill worker.	220 tins
Supply cartons, 10 ounce Get cartons from storage, open paper bag, place on bag stand.	750 cases
Sugar supply Get bag of sugar from pallet, open, dump into hopper, fold and stack empty bag.	1,500 pounds

APPENDIX TABLE B

Installed Cost, Estimated Use Life, and Annual Fixed Charge for Equipment Items Used in Plants Processing Strawberries for Freezing, California, 1958

Item	Installed cost[a]	Estimated use life	Annual fixed charge[b]
	dollars	years	dollars
Bag stand	50.00	15	6.59
Bag unloader	1,080.00	10	178.20
Capper, 16-ounce cups	3,145.00	10	518.93
Carton chute per foot	20.00	15	2.63
Case chute per foot	5.00	15	.66
Casing machine	6,485.00	10	1,070.03
Closer, 10- and 16-ounce fiberboard cartons	--	--	950.00[c]
Closer, 6½-pound tin	5,005.00	10	825.83
Conveyors			
Carton feed to filler (power from filler)	160.00	15	21.07
"Check weigh" station to cup capper	320.00	15	42.14
plus cost per foot	25.00	15	3.29
Cup capper to "case in" station	765.00	15	100.75
Cup filler to "check weigh" station	320.00	15	42.14
plus cost per foot	25.00	15	3.29
Dumper to shaker-washer	475.00	15	62.56
plus cost per foot over 10 feet	35.00	15	4.61
Filler to seamer	745.00	15	98.12
Grader to slicer	560.00	15	73.75
Pallet, powered with controls	1,360.00	15	179.11
Seamer to "case in" station	765.00	15	100.75
Sort belt to grader	355.00	15	46.75
plus cost per foot	21.00	15	2.77
Skate, 10-foot section	50.00	15	6.59
Steel roller, 10-foot section	75.00	15	9.88
Crate, berry, per thousand	22.14	10	3.99[d]
Crate washer	1,275.00	10	210.38
plus cost per foot	12.00	10	1.98
Dumper, crate	2,825.00	10	466.13
Fillers			
Cartons, 10 and 16 ounce			
110-carton - per-minute capacity	3,155.00	10	520.58
220-carton - per-minute capacity	7,120.00	10	1,174.80
Tins, 6½ pound, 25-tin - per-minute capacity	8,125.00	10	1,340.63
Cups, 16 ounce, hand pack	2,225.00	10	367.13
Fill hopper, 30-pound tin	200.00	10	33.00
Fork-lift truck, 4,000-pound capacity	5,775.00	10	952.88
Interchanger crate	400.00	15	52.68
Mixing screw, sliced berry, with sugar controls	1,880.00	10	310.20
Mixing sdrew, whole berry, with sugar controls	1,115.00	10	183.98
Pallet, hundred	325.00	10	58.50[d]
Quality sort belt, 30" x 25'	1,600.00	15	210.72

(Continued on next page.)

Appendix Table B continued.

Item	Installed cost[a/]	Estimated use life	Annual fixed charge[b/]
	dollars	years	dollars
Scales			
Check weigh, 3-pound capacity	190.00	15	25.02
Floor, 2,600-pound capacity	1,430.00	15	188.33
Platform, 50-pound capacity	260.00	15	34.24
Shaker-washer	1,445.00	10	238.43
Sealer and compressor, 500-case per hour capacity	5,295.00	10	873.68
Size grader, shaker type			
5-ton capacity	1,310.00	10	216.15
10-ton capacity	2,245.00	10	370.43
Slicer, cloverleaf	910.00	10	150.15
Sortout section			
Dewatering belt	530.00	15	69.80
Flume	55.00	15	7.24
plus cost per foot	17.25	15	2.27
Scale, platform	260.00	15	34.24
Stapler, case	675.00	10	111.38
Tables, case stamp and case form	25.00	15	3.29

a/ Includes f.o.b. price, sales tax, transportation, and installation including plumbing and electrical work associated with the particular piece of equipment.

b/ Estimated on the basis of installed cost. Includes fixed repair, 1.5 per cent; insurance, 1.0 per cent; interest on investment, 3.0 per cent (approximately 5.5 per cent on undepreciated balance); property tax, 1.0 per cent; and depreciation calculated according to estimated use life (10-year items, 10.0 per cent; and 15-year items, 6.67 per cent).

c/ Annual rental charge.

d/ Same as b/ except fixed repair is 3.0 per cent.

APPENDIX TABLE C

Costs of Miscellaneous Equipment Items Used in Plants Processing Strawberries for Freezing, California, 1958

Item	Cost
	dollars
Blow torch	14
Cleaner--steam, portable	965
Drill--hand, electric	80
Drill press	145
Grinder	55
Heater--water, gas	175
Laboratory equipment	
Scales	253
Blender	45
Sink, 66 inch, stainless steel top	325
Miscellaneous	up to 250
Pipe threaders, cutters, taps	50
Saw, band	80
Sewage equipment	
Sewage screen	3,100
Conveyor from pit, screw type	550
Garbage tanks, 200 gallon	100
Garbage tanks, 300 gallon	150
Stencil cutter	295
Truck, hand	40
Vise, portable	35
Vise, stationary	60
Welder--arc, complete	395
Miscellaneous hand tools	up to 250

APPENDIX TABLE D

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Casing 16-Ounce Cartons, 24 Cartons Per Case, with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (cases per hour)	Workers required[a]				Variable costs per hour			Equipment replacement costs and annual fixed charge[b]						
	Stamp case[c]	Form case[c]	Fill case[c]	Set off[d]	Labor[e]	Power and repair[f]	Total[g]	Stapler	Casing machine	Sealer and compressor	Conveyors[h]	Miscellaneous[i]	Total replacement cost	Annual fixed charge[j]
	number				dollars									
	Method A--stapled case, manual filling, manual sealing													
100	k/	1	1	1	5.38	.05	5.43	675			75	160	910	142
200	1	1	2	2	10.77	.05	10.82	675			75	160	910	142
300	1	2	3	2	14.25	.10	14.35	1,350			75	260	1,685	267
400	1	2	4	3	17.89	.10	17.99	1,350			75	260	1,685	267
500	1	3	4	3	19.63	.11	19.74	1,350			150	260	1,760	277
600	1	3	5	4	23.28	.15	23.43	2,025			150	360	2,535	401
700	2	3	6	5	28.66	.15	28.81	2,025			150	360	2,535	401
800	2	4	7	5	32.14	.20	32.34	2,700			150	520	3,370	534
900	2	4	7	6	34.05	.20	34.25	2,700			225	520	3,445	544
1,000	2	5	8	6	37.52	.20	37.72	2,700			225	520	3,445	544
	Method B--nonstapled case, manual filling, mechanical sealing													
100	k/	1	1	1	5.38	.30	5.68			5,295	75	85	5,455	895
200	1	1	2	1	8.86	.30	9.16			5,295	75	85	5,455	895
300	1	2	3	2	14.25	.30	14.55			5,295	75	85	5,455	895
400	1	2	4	2	15.98	.30	16.28			5,295	75	85	5,455	895
500	1	2	4	2	15.98	.59	16.57			10,590	150	110	10,850	1,782
600	1	3	5	3	21.37	.59	21.96			10,590	150	110	10,850	1,782
700	2	3	6	3	24.85	.59	25.44			10,590	150	110	10,850	1,782
800	2	3	7	3	26.58	.60	27.18			10,590	150	170	10,910	1,789
900	2	4	7	4	30.23	.89	31.12			15,885	225	195	16,305	2,676
1,000	2	4	8	4	31.97	.89	32.86			15,885	225	195	16,305	2,676
	Method C--nonstapled case, mechanical filling, mechanical sealing													
100	k/	1		1	3.65	.63	4.29		6,485	5,295	75	85	11,940	1,965
200	1	1		1	5.38	.63	6.02		6,485	5,295	75	85	11,940	1,965
300	1	1		2	7.29	.63	7.93		6,485	5,295	75	85	11,940	1,965
400	1	1		2	7.29	.63	7.93		6,485	5,295	75	85	11,940	1,965
500	1	2		2	9.03	1.26	10.29		12,970	10,590	150	110	23,820	3,922
600	1	2		3	10.94	1.26	12.20		12,970	10,590	150	110	23,820	3,922
700	2	2		3	12.68	1.26	13.94		12,970	10,590	150	110	23,820	3,922
800	2	2		3	12.68	1.26	13.94		12,970	10,590	150	170	23,880	3,922
900	2	3		4	16.32	1.89	18.21		19,455	15,885	225	195	35,760	5,886
1,000	2	3		4	16.32	1.89	18.21		19,455	15,885	225	195	35,760	5,886

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a/ Labor standards (cases): stamp case--640; form case, method A--235; form case, method B--280; form case, method C--440; fill case, method A--120; fill case, method B--130; set off, method A--175; set off, methods B and C--270 (units, cases per hour).

b/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

c/ Hourly wage, $1.64.

d/ Hourly wage, $1.80.

e/ Base wage plus 6 per cent to cover F.I.C.A., State Unemployment, and paid holidays.

f/ Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

g/ Includes labor, power, and variable repairs.

h/ Includes charges for skate conveyors at $4.20 per foot and steel roller conveyors at $6.75 per foot.

i/ Includes charges for case-stamping tables, stencil wheels, case-forming tables, glue stands, and case chutes where required.

j/ Calculated as percentage of replacement cost of equipment. Includes depreciation, 10 per cent; fixed repair, 1.5 per cent; insurance, 1 per cent; taxes, 1 per cent; and interest, 3 per cent (approximately 5.5 per cent on undepreciated balance). Total of 16.5 per cent.

k/ Job requires small amount of time and is performed by other workers.

APPENDIX TABLE E

Labor Requirements, Hourly Variable Costs, and Equipment Replacement and Annual Fixed Charge for Casing 6½-Pound Tins, 6 Tins Per Case, with Respect to Plant-Output Capacity in Plants Processing Strawberries for Freezing, California, 1958

Output capacity (cases per hour)	Workers required[a]				Variable costs per hour			Equipment replacement costs and annual fixed charge[b]					
	Stamp case[c]	Form case[c]	Fill case[c]	Tail off[d]	Labor[e]	Power and repair[f]	Total[g]	Stapler	Sealer and compressor	Conveyors	Miscellaneous	Total replacement cost	Annual fixed charge
	number				dollars								
	Method A--stapled case, manual casing, manual sealing												
50	h/	1	1	1	5.38	.05	5.43	675		75	160	910	142
100	h/	1	1	1	5.38	.05	5.43	675		75	160	910	142
150	1	1	2	2	10.77	.05	10.82	675		75	160	910	142
200	1	1	2	2	10.77	.05	10.82	675		75	160	910	142
250	1	2	3	2	14.25	.06	14.31	675		150	235	1,060	162
300	1	2	3	3	16.15	.11	16.26	1,350		150	260	1,760	277
	Method B--nonstapled case, manual casing, mechanical sealing												
50	h/	1	1	1	5.38	.30	5.68		5,295	125	85	5,505	901
100	h/	1	1	1	5.38	.30	5.68		5,295	125	85	5,505	901
150	1	1	2	1	8.86	.30	9.16		5,295	125	85	5,505	901
200	1	1	2	2	10.77	.30	11.07		5,295	125	85	5,505	901
250	1	1	2	2	10.77	.32	11.09		5,295	475	85	5,855	947
300	1	2	3	2	14.25	.32	14.57		5,295	475	85	5,855	947

a/ Labor standards: stamp case--640; form case, method A--235; form case, method B--280; fill case, method A--120; fill case, method B--130; set off, method A--130; set off, method B--180.(units, cases per hour).

b/ See Appendix Table B for list of equipment replacement costs and annual fixed charges.

c/ Hourly wage, $1.64.

d/ Hourly wage, $1.80.

e/ Base wage plus 6 per cent to cover F.I.C.A., State Unemployment, and paid holidays.

f/ Electric power estimated at 2.5 cents per motor horsepower. Repair estimated at 0.5 per cent of replacement cost of equipment per 100 operating hours.

g/ Includes labor, power, and variable repairs.

h/ Job performed by "form case" worker.